Analysis of the Availability of Bituminous Coal in the Appalachian Region

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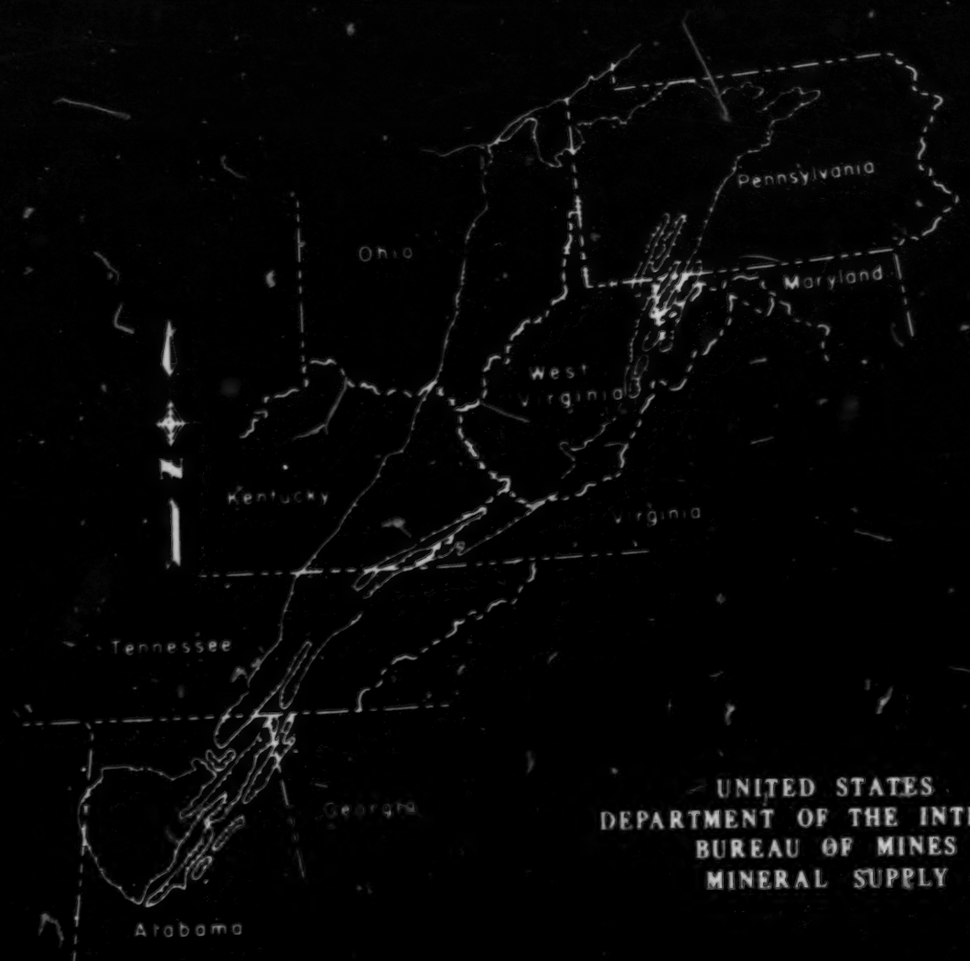

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
MINERAL SUPPLY

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UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
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ABSTRACT

The U.S. Bureau of Mines, under funding by the Office of Air Programs, Environmental Protection Agency, conducted a study for the purpose of obtaining information on the availability of bituminous coal, by sulfur content, in the Appalachian Region.

During 1968 and 1969, operators of bituminous coal mines that produced 100,000 tons or more in 1967 in Alabama, eastern Kentucky, Maryland, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia responded to a special questionnaire, or were personally contacted, to provide the data presented in this report.

A remaining reserve of 31.4 billion short tons of bituminous coal was reported as of December 31, 1967. At 1967 prices, 5.7 billion tons was reported as recoverable; an additional 7.7 billion tons could be recovered with a price increase up to and over $2.00 per ton. Of the reported recoverable reserve, 34 percent contains 1.0 percent or less sulfur. In the Appalachian Region, West Virginia leads in both total recoverable reserves and those reserves low in sulfur content. Pennsylvania ranked second in recoverable reserves, virtually all of which contained an excess of 1.0 percent sulfur. A reported recoverable reserve of 1.2 billion tons was located in eastern Kentucky--about half is 1.0 percent sulfur or less.

Reserves reported as captive accounted for 8 percent of the total remaining reserves; 40 percent was reported as commercially available on the open market. The remainder was reported as undifferentiated, neither captive nor commercial.

It is estimated that 87 percent of the land surface of the States of the Appalachian Region is in private ownership. The remainder belongs to Federal, State, or local governments. Frequently, ownership of the coal is segregated from that of the surface land. Some private ownership of coal occurs on government-owned land. Similar segregation may exist between governmental agencies or between private persons.

Of the 266 million tons of coal reported produced in 1967, by the selected companies, about 43 percent was at a sulfur level of 1.0 percent or less. Shipments to electric utility plants were almost 117 million tons. Over 90 million tons of this contained in excess of 1.0 percent sulfur; almost 104 million tons was obtained from commercial operations, and 13 million tons from captive mines. Coal for metallurgical purposes accounted for 81 million tons. An additional 24 million tons, mostly high-quality coking coal, was exported. The balance of 44 million tons was used for other industrial purposes and retail sales.

Planned future production and employment are discussed. Coal analytical data are also provided. Differences in coal reserve estimates are discussed.

INTRODUCTION

The coal resources of the Appalachian Region are known to be plentiful. As an energy source, bituminous coal is important to the development and continuous industrial expansion of our Nation. In recent years, considerable concern has been expressed regarding the supply of coal containing low quantities of sulfur. Therefore, from the standpoint of quality, the supply of bituminous coal may be limited.

The U.S. Bureau of Mines, under funding by the Office of Air Programs, Environmental Protection Agency, conducted a survey of the availability of coal by sulfur content in the Appalachian Region (figure 1). The principal purpose of the study was to determine the quantity of coal reserves by sulfur content, their location by county, and type of reserve. A secondary purpose was to gain insight into the production and consumption of coal by sulfur content, productive capacity of mines, and work force. Data from companies that produced over 100,000 tons of coal in 1967 were compiled, analyzed, and interpreted.

Data on reserves were reported by the companies in two major categories--remaining and recoverable. Reserves were classified as commercial and captive, and these were subdivided into reserves assigned to operating mines, new mines scheduled by 1973, and not assigned to mines. Production was reported as to the quantity produced by shifts. Distribution was determined by consumer uses. Most of the questions on coal reserves and production were answered by the companies responding to the questionnaire. However, all companies did not report reserves minable at 1967 f.o.b. mine values, estimated total capital costs for new mines, production and work force by shifts, shipments by consumer uses, and planned production.

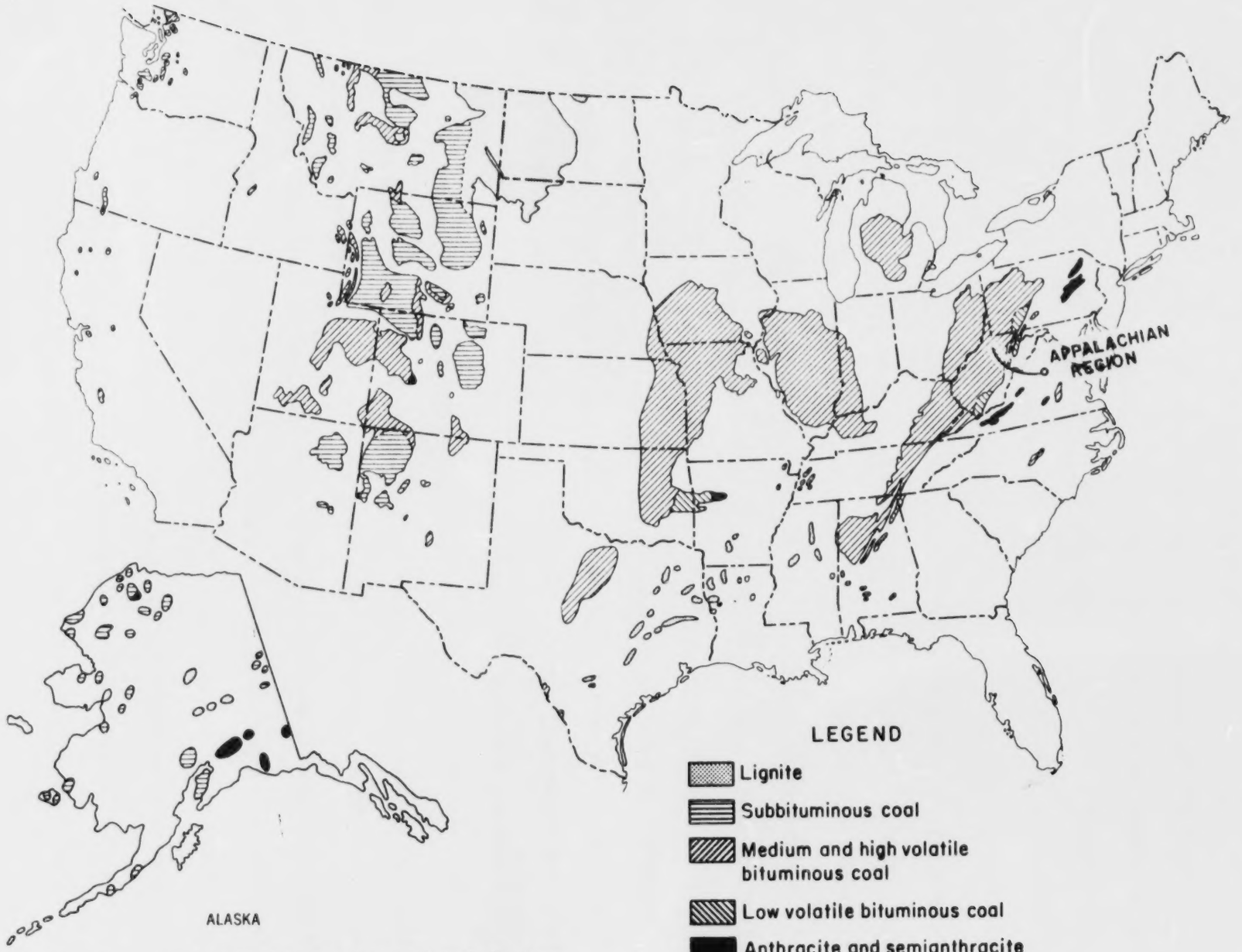


FIGURE 1. - Coalfields of the United States.

Numerous State, Federal, and industry reports have been published regarding coal reserves. This report is the first directed to a comprehensive appraisal of coal reserves in the Appalachian Region by sulfur content. The report is a part of the Bureau of Mines continuing role in the conservation and development of mineral resources and is the first of a series of reports to be prepared on coal reserves. Future reports will summarize coal reserves in the United States.

ACKNOWLEDGEMENTS

This report represents the results of a study of the availability of coal by sulfur content in the Appalachian Region. The study was conducted by the Bureau of Mines for the Environmental Protection Agency. The cooperation of the bituminous coal producers that responded to the canvass or to personal interviews is gratefully acknowledged. Appreciation for the courtesies and information received is extended to many informed individuals in industry and local governmental agencies.

DEFINITIONS OF TERMS

1. Ash - Inorganic residue remaining after ignition of combustible substances, determined by definite prescribed methods.
2. Ash-softening Temperature (AST) - Temperature at which a cone of coal ash fuses down to a spherical lump with a height equal to the width of the base and expressed in degrees Farenheit.
3. As-Received (A.R.) - Analytical results of tests on the analyzed sample calculated to the as-received in the laboratory or as-sampled basis.
4. Available Reserves - Coal reserves available for mining.
5. Btu (British thermal unit) - The quantity of heat needed to raise the temperature of one pound of water 1° Farenheit (equal to 252 calories).
6. Captive Mine - A mine which produces coal for use by the same company or parent company.
7. Captive Reserves - Coal reserves owned by a company for use in supplying its present or future needs.
8. Cleaned Coal - Coal recovered after processing by mechanical means for the purpose of reducing the amount of free impurities.
9. Coal Reserves - An unqualified, general term, referring to any unmined coal.
10. Commercial Mine - A mine producing coal to be supplied to purchasers in general.
11. Commercial Reserves - Coal reserves for future production to supply purchasers in general.

12. Committed Reserves - Reserves of coal committed by contract to supply a specific user.

13. Depleted Original Resource - Original estimated coal resource from which all production and mining losses to December 31, 1967, have been deducted.

14. Dry Basis - Analytical results of tests on the analyzed sample calculated to a moisture-free basis.

15. Dry Coal - Analytical results of tests on the analysis sample calculated to a moisture-free basis.

16. Export Coal - Coal that is shipped to foreign countries.

17. Free Swelling Index (FSI) - A measure of the increase in volume of a coal when it is heated without restriction under specific heating conditions.

18. Hardgrove Grindability - An index of the relative ease with which different coals may be pulverized, compared with standard coals, using a Hardgrove grindability machine.

19. Long-term Contract - A contract committing coal production for a specified period of years.

20. Metallurgical Coal - Coal for the manufacture of coke for the steel industry.

21. Minable Reserves - Coal reserves that are available for mining.

22. Moisture (M) - Essentially water, quantitatively determined by definite prescribed methods.

23. Open Market - Available to purchasers in general.

24. Range (L H) - The lowest (L) and highest (H) values.

25. Raw Coal - Coal that has received no preparation, except perhaps crushing and sizing.

26. Recoverable Reserves - Coal reserves that can be mined economically with present technology and equipment.

27. Remaining Reserves - Coal remaining in the ground after deduction from original in-place reserves of all production and mining losses to December 31, 1967.

28. Reported - Information reported by coal companies responding to questionnaire No. 6-1418-X.

29. Resource - Total coal in the ground.

30. Sulfur Percent - The total sulfur (organic, pyritic, and sulfate) content of coal, by weight, expressed as a percentage.

31. Volatile Matter (Vol. Mat.) - Those products, exclusive of moisture, given off by the coal as a gas or vapor, determined by prescribed methods.

32. Yield - The percentage of coal recovered from the cleaning process.

PROCEDURE

A special questionnaire, No. 6-1418-X, approved by the Bureau of the Budget, was used to canvass selected coal operators in the bituminous coalfields of the Appalachian Region (figure 1). In July 1968, 701 operators of mines that produced more than 100,000 tons of coal in 1967 were mailed the questionnaire. Fifty-one percent of the 701 operators reporting data returned the questionnaires to the U.S. Bureau of Mines. Forty-nine percent of the mine operators, for which data is included in this report, did not return the questionnaires and were subsequently telephoned or visited by project engineers and geologists.

In total, data were collected from 91 percent of the 701 companies selected for this study, representing more than 68 percent of the total coal produced from the Appalachian Region in 1967.

The procedure followed in evaluating and processing data reported on the questionnaires is shown in figure 2.

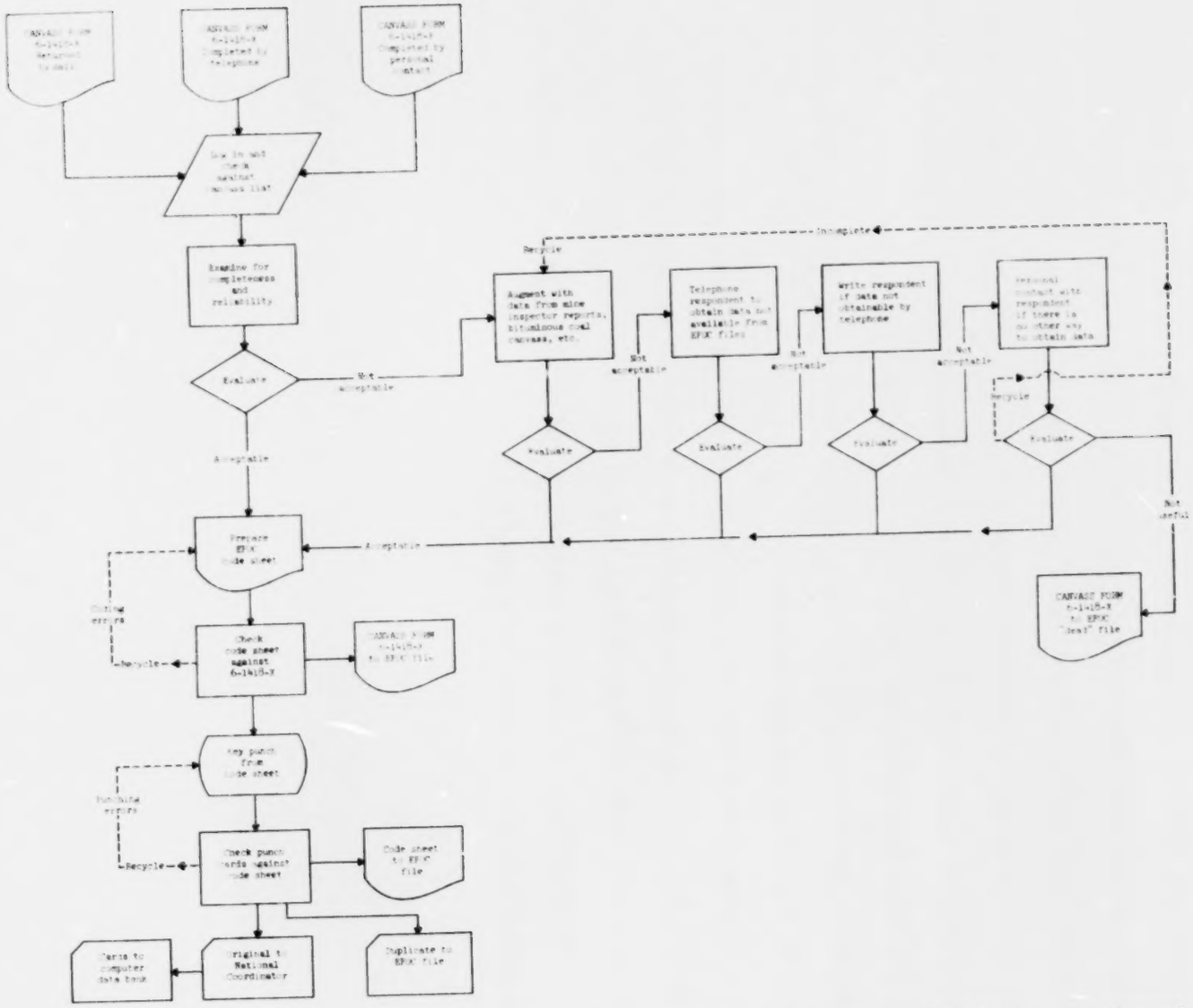


FIGURE 2. - Processing procedure of coal availability questionnaires.

EPIX = Eastern Field Operation Center.

COAL RESERVES

Coal reserves were reported in two major categories: remaining reserves and recoverable reserves. The remaining reserves were reported by State and were divided into three categories: commercial, captive, and other. Each of these three were further divided as to reserves associated with operating mines, scheduled new mines, and not assigned to mines. The reserve categories were further divided according to eight ranges of sulfur content. The recoverable reserves were divided by State and into the same divisions as the remaining reserves except for the three mining categories.

A total of 31.4 billion tons of coal was reported as remaining reserves in eight States of the Appalachian Region as of December 31, 1967 (tables 1 and 2). Thirty-nine percent of these coal reserves contain 1.0 percent or less sulfur. Operating mines were associated with 34 percent of the remaining reserves. New mines scheduled to operate before 1973 were associated with 15 percent of these reserves. Thus, the majority of the reported remaining reserves (51 percent) are not assigned to operating or scheduled new mines.

The coal reserves shown on the principal tables and figures are those reported (Form 6-1418-X) exclusively by operators of mines producing 100,000 tons or more. These reported reserves are related to, but are not the same as the remaining reserves estimated by the U.S. Geological Survey in Bulletin 1275 (1)[1/].

1/ Underlined numbers in parentheses refer to items in the list of

TABLE 1. - Reported bituminous coal reserves, Appalachian Region, December 31, 1967, by State, sulfur content, and value

(Million short tons)

State	Sulfur content (Percent)	REMAINING RESERVES: Assigned to mines 1/	Not assigned to mines	Total	Minable at 1967 value	RECOVERABLE RESERVES CUMULATIVE TOTAL: +0 - $0.50	+.51 - 1.00	+1.01 - 2.00	+2.00
ALABAMA	≤0.3		3/ W	3/ W					
	≤0.5		W	W					
	0.6-1.0	211.50	918.86	1,130.36	W	54.46	69.47	89.50	98.20
	1.1-1.5	91.18	525.13	616.31	W	28.75	36.75	53.25	285.25
	1.6-2.0	55.93	152.80	208.73	W	W	W	W	W
	2.1-3.0	W	W	112.23	---	W	W	W	W
	≥3.1	W	---	W	---	---	---	---	W
	(2)	---	W	W	---	---	---	---	---
	Total	384.24	1,842.10	2,226.34	50.10	91.62	122.43	158.96	446.46
KENTUCKY, eastern	≤0.3	---	---	---	---	---	---	---	---
	≤0.5	W	W	234.00	83.27	83.57	83.57	83.57	84.27
	0.6-1.0	W	W	1,293.09	210.23	288.45	361.22	369.00	497.34
	1.1-1.5	W	W	557.63	86.67	134.72	216.77	244.17	247.77
	1.6-2.0	102.62	58.24	160.86	55.64	77.21	100.91	100.91	100.91
	2.1-3.0	11.06	47.40	58.46	15.14	22.06	27.46	34.46	34.46
	≥3.1	W	W	275.22	---	W	W	W	201.79
	(2)	W	W	24.92	---	W	W	W	10.60
	Total	W	W	2,604.18	450.95	618.55	807.47	876.65	1,177.14
MARYLAND	≤0.3	---	---	---	---	---	---	---	---
	≤0.5	---	---	---	---	---	---	---	---
	0.6-1.0	---	---	---	---	---	---	---	---
	1.1-1.5	---	---	---	---	---	---	---	---
	1.6-2.0	W	---	W	.10	.10	.10	.10	.10
	2.1-3.0	W	W	W	.60	W	W	W	W
	≥3.1	---	---	---	---	---	---	---	---
	(2)	---	72.20	72.20	---	---	---	---	---
	Total	W	W	80.95	.70	W	W	W	W

TABLE 1. - Reported bituminous coal reserves, Appalachian Region, December 31, 1967, by State, sulfur content, and value - Continued

(Million short tons)

State	Sulfur content (Percent)	REMAINING RESERVES				RECOVERABLE RESERVES CUMULATIVE TOTAL			
		Assigned to mines 1/	Not assigned to mines	Total	Minable at 1967 value	+0 - $0.50	+.51 - 1.00	+1.01 - 2.00	+2.00
OHIO	≤0.3	---	---	---	---	---	---	---	---
	≤0.5	---	---	---	---	---	---	---	---
	0.6-1.0	---	---	---	---	---	---	---	---
	1.1-1.5	W	---	[W	---	---	---	---	---
	1.6-2.0	W	W	[14.55	W	W	W	W	W
	2.1-3.0	451.60	46.79	498.39	W	W	W	W	W
	≥3.1	783.16	1,489.18	2,272.34	356.17	391.42	556.13	575.74	585.62
	(2)	---	---	---	---	---	---	---	---
	Total	W	W	2,785.28	434.67	546.25	796.66	831.92	891.80
PENNSYLVANIA	≤0.3	---	---	---	---	---	---	---	---
	≤0.5	---	---	---	---	---	---	---	---
	0.6-1.0	113.75	27.01	140.76	36.04	36.36	40.71	42.28	42.28
	1.1-1.5	356.14	277.55	633.69	46.80	52.04	59.09	59.94	59.94
	1.6-2.0	W	W	986.53	416.67	441.12	484.92	515.11	524.89
	2.1-3.0	1,064.90	1,275.78	2,340.68	487.56	494.49	542.76	675.46	757.33
	≥3.1	W	W	1,087.98	636.20	650.43	727.23	738.89	784.34
	(2)	W	W	411.46	28.24	33.24	33.27	43.27	58.99
	Total	2,917.58	2,683.52	5,601.10	1,651.51	1,707.68	1,887.98	2,074.95	2,227.77
TENNESSEE	≤0.3	---	---	---	---	---	---	---	---
	≤0.5	---	---	---	---	---	---	---	---
	0.6-1.0	W	W	138.95	W	3.60	24.25	67.00	67.00
	1.1-1.5	W	---	W	---	W	W	W	W
	1.6-2.0	---	---	---	---	---	---	---	---
	2.1-3.0	W	---	W	W	.47	1.65	1.65	1.65
	≥3.1	W	W	101.70	W	W	1.19	1.19	66.19
	(2)	W	---	W	---	W	W	W	-
	Total	W	W	250.79	.67	W	W	W	-

TABLE 1. - Reported bituminous coal reserves, Appalachian Region, December 31, 1967, by State, sulfur content, and value - Continued

(Million short tons)

State	Sulfur content (Percent)	REMAINING RESERVES: Assigned to mines 1/	Not assigned to mines	Total	Minable at 1967 value	RECOVERABLE RESERVES CUMULATIVE TOTAL: +0 - $0.50	+.51 - 1.00	+1.01 - 2.00	+2.00
VIRGINIA	≤0.3	---	---	---	---	---	---	---	---
	≤0.5	---	---	---	---	---	---	---	---
	0.6-1.0	1,105.69	721.15	1,826.83	224.07	253.40	316.21	474.39	482.29
	1.1-1.5	W	W	W	W	W	W	W	W
	1.6-2.0	---	W	W	8.23	9.08	15.08	32.58	32.81
	2.1-3.0	W	W	37.50	W	W	W	W	W
	≥3.1	W	---	W	W	W	W	W	W
	(2)	W	W	W	---	---	---	---	---
	Total	W	W	2,072.12	236.71	267.48	350.67	527.35	538.48
WEST VIRGINIA	≤0.3	---	---	---	---	---	---	---	---
	≤0.5	W	W	W	16.85	16.85	16.85	16.85	16.85
	0.6-1.0	4,162.22	3,208.38	7,370.60	1,808.86	2,035.58	2,629.21	3,026.42	3,261.32
	1.1-1.5	224.45	340.77	565.22	80.13	93.38	210.50	274.60	341.60
	1.6-2.0	124.50	---	124.50	29.59	35.80	52.80	55.29	68.50
	2.1-3.0	1,209.89	1,712.24	2,922.13	390.79	499.63	1,426.43	1,542.61	1,542.73
	≥3.1	1,705.72	2,632.39	4,338.11	359.84	722.32	2,173.39	2,482.29	2,482.29
	(2)	W	W	W	206.50	240.81	250.11	257.43	260.93
	Total	7,744.05	8,064.46	15,808.51	2,892.56	3,644.37	6,759.07	7,655.49	7,974.21
TOTAL ALL STATES	≤0.3	---	3/ W	3/ W	---	---	---	---	---
	≤0.5	183.07	220.45	403.52	100.12	100.42	100.42	100.42	101.12
	0.6-1.0	6,477.87	5,422.72	11,900.59	2,308.20	2,671.85	3,441.07	4,068.59	4,448.42
	1.1-1.5	1,046.65	1,356.55	2,403.20	238.55	313.14	535.84	644.69	947.29
	1.6-2.0	987.15	580.99	1,568.14	516.53	570.85	661.13	711.53	775.65
	2.1-3.0	2,780.78	3,201.81	5,982.59	967.23	1,169.45	2,249.78	2,523.31	2,659.80
	≥3.1	3,037.38	5,048.06	8,085.44	1,352.50	1,778.45	3,479.19	3,846.36	4,127.79
	(2)	691.44	394.35	1,085.79	234.74	279.10	290.93	308.25	340.12
	Total	15,204.34	16,224.93	31,429.27	5,717.87	6,883.26	10,758.36	12,203.15	13,400.19

W Withheld to avoid disclosing individual company confidential data.

1/ Includes remaining reserves assigned to operating mines and new mines scheduled before 1973.

2/ Sulfur content not reported.

3/ Included with ≤0.5 sulfur content.

TABLE 2. Reported bituminous coal reserves, Appalachian Region, December 31, 1967, by sulfur content, type of market, and value

(Million short tons)

Type of market	Sulfur content (Percent)	REMAINING RESERVES				RECOVERABLE RESERVES CUMULATIVE TOTAL			
		Assigned to mines 1/	Not assigned to mines	Total	Minable at 1967 value	+0 - $0.50	+.51 - 1.00	+1.01 - 2.00	+2.00
COMMERCIAL	≤0.3	---	---	---	---	---	---	---	---
	≤0.5	84.10	---	84.10	W	W	W	W	W
	0.6-1.0	W	W	W	1,528.45	1,725.80	1,946.18	2,137.91	2,333.49
	1.1-1.5	W	W	645.41	124.01	182.20	240.40	308.13	325.27
	1.6-2.0	849.79	---	849.79	354.03	396.68	466.95	491.85	515.07
	2.1-3.0	W	---	W	677.81	867.03	1,044.57	1,262.39	1,325.95
	≥3.1	2,953.49	---	2,953.49	722.77	1,101.17	1,211.12	1,495.02	1,616.74
	(2)	W	---	W	W	W	W	W	W
	Total	W	W	12,516.74	3,642.13	4,515.39	5,154.23	5,950.31	6,387.95
CAPTIVE	≤0.3	---	---	---	---	---	---	---	---
	≤0.5	98.97	---	98.97	W	W	W	W	W
	0.6-1.0	1,357.70	---	1,357.70	275.15	367.43	438.07	449.07	457.77
	1.1-1.5	W	---	W	46.25	49.25	56.25	66.25	72.65
	1.6-2.0	137.36	---	137.36	W	W	W	W	W
	2.1-3.0	W	---	W	W	W	W	W	W
	≥3.1	W	W	160.73	35.27	47.27	71.69	71.69	71.69
	(2)	W	---	W	---	W	W	W	W
	Total	W	W	2,671.65	448.75	556.53	665.00	686.00	701.10
OTHER	≤0.3	---	3/ W	3/ W	---	---	---	---	---
	≤0.5	---	220.45	220.45	W	W	W	W	W
	0.6-1.0	W	W	W	504.60	578.62	1,056.82	1,481.61	1,657.16
	1.1-1.5	---	W	W	68.29	81.69	239.19	270.31	549.37
	1.6-2.0	---	580.99	580.99	W	W	W	W	W
	2.1-3.0	---	3,201.81	3,201.81	W	W	W	W	W
	≥3.1	W	W	4,971.22	594.46	630.01	2,196.38	2,279.65	2,439.36
	(2)	---	394.35	394.35	47.90	84.61	93.94	101.26	117.41
	Total	W	W	16,240.88	1,626.99	1,811.34	4,939.13	5,566.84	6,311.24

TABLE 2. Reported bituminous coal reserves, Appalachian Region, December 31, 1967, by sulfur content, type of market, and value - Continued

(Million short tons)

Type of market	Sulfur content (Percent)	REMAINING RESERVES				RECOVERABLE RESERVES CUMULATIVE TOTAL			
		Assigned to mines 1/	Not assigned to mines	Total	Minable at 1967 value	+0 - $0.50	+.51 - 1.00	+1.01 - 2.00	+2.00
TOTAL	≤0.3	---	3/ W	3/ W	---	---	---	---	---
	≤0.5	183.07	220.45	403.52	100.12	100.42	100.42	100.42	101.12
	0.6-1.0	6,477.87	5,422.72	11,900.59	2,308.20	2,671.85	3,441.07	4,068.59	4,448.42
	1.1-1.5	1,046.65	1,356.55	2,403.20	238.55	313.14	535.84	644.69	947.29
	1.6-2.0	987.15	580.99	1,568.14	516.53	570.85	661.13	711.53	775.65
	2.1-3.0	2,780.78	3,201.81	5,982.59	967.23	1,169.45	2,249.78	2,523.31	2,659.80
	>3.1	3,037.38	5,048.06	8,085.44	1,352.50	1,778.45	3,479.19	3,846.36	4,127.79
	(2)	691.44	394.35	1,085.79	234.74	279.10	290.93	308.25	340.12
	Total	15,204.34	16,224.93	31,429.27	5,717.87	6,883.26	10,758.36	12,203.15	13,400.19

W Withheld to avoid disclosing individual company confidential data.
1/ Includes remaining reserves assigned to operating mines and new mines scheduled before 1973.
2/ Sulfur content not reported.
3/ Included with ≤0.5 sulfur content.

Coal reserves are owned by governmental agencies, landholding companies, and private landowners, but these owners are not mine operators, and their reserves were not obtainable by the questionnaire (No. 6-1418-X).

West Virginia is the most important State for bituminous coal reserves in the Appalachian Region, containing 50 percent of the remaining reserves reported on questionnaire No. 6-1418-X. This State leads in reported reserves that contain 1.0 percent or less sulfur, with 60 percent of the remaining reserves and 72 percent of the recoverable reserves.

Comparison of Reserve Estimates

Reserve estimates commonly are not identical because different assumptions are used in calculating coal reserves. For instance, the reported remaining reserves assembled for the present report are not the same as those published in the U.S. Geol. Survey Bulletin 1275, titled, "Coal Resources of the United States January 1, 1967" (1) or those of U.S. Bureau of Mines Information Circular 8312 titled "Sulfur Content of United States Coals" (reserves as of December 31, 1964) (4). There is no formula to assure that any estimate is indisputable.

The U.S. Geological Survey methods for estimating reserves are described on pages 14 and 15 of Bulletin 1275, and quoted below:

> "As a first step in preparing statewide estimates of the type presented in table 1, all available information is gathered and recorded on individual coal bed maps. Sources of information include the publications and records of the U.S. Geological Survey and State geological surveys, maps and drill records of coal

mining companies, information in the files of State mine inspectors and railroad companies, records of exploration for petroleum and natural gas, records of water-well drilling companies, and, occasionally, private records obtained from individuals. To translate this information into estimates of tonnage, a series of definitions and standardized procedures must be employed.

"First, two cutoff points must be established--one at the minimum thickness of coal included in the estimate, and the other at the maximum thickness of overburden allowed above the coal. A very conservative estimate may include only resources in thick beds and under slight overburden--in other words, resources that could be recovered profitably under current mining conditions. A more inclusive estimate, on the other hand, may consider thinner, more impure, and more deeply buried coal as recoverable by improved methods when more easily mined deposits have been exhausted.

"Next, the weight or specific gravity of the coal must be determined or assumed, and where the continuity of a coal bed is unknown a method must be selected to estimate its probable extent, based on the available outcrop, mine, or drill data.

"The way in which these and other factors are treated can vary greatly with individual estimators. For this reason, an estimate of coal resources has meaning only when considered in relation to the methods used in obtaining it".

The bituminous coal resources of the United States published in U.S. Geological Survey Bulletin 1275 include beds down to 14 inches thick with a maximum overburden thickness of 3,000 feet. The depleted remaining resources were determined by subtracting production and losses (assumed to equal production) from the original resource.

Coal reserve estimates contained in U.S. Bureau of Mines Information Circular 8312 were obtained by depleting the remaining reserve estimates in U.S. Geological Survey Bulletin 1136 (2). The total coal production and mining losses for the years between the U.S. Geological Survey remaining reserve estimate and the data of the desired estimate were subtracted from the published reserves.

The reported remaining coal reserves obtained on Form 6-1418-X for this report are smaller than those published in Information Circular 8312 (published reserves) (table 3). The variation resulted because the source of data and criteria for calculating reserves differed, of which the more significant points are listed below:

A. Source of data.

   1. Only companies producing 100,000 tons or more in 1967 were canvassed.
   2. Information reported on Form 6-1418-X was obtained on a voluntary response basis.
   3. No field check in the form of exploration and mapping was made to assure correctness of the data.

TABLE 3. - Comparison of remaining reserves reported on Form 6-1418-X with those published in IC-8312 for the Appalachian Region

(Million tons)

State	≤1.0 percent sulfur content		≤1.1 percent sulfur content	
	Reported[1] 6-1418-X	Published[2] IC-8312	Reported[1] 6-1418-X	Published[2] IC-8312
Alabama	[3] 1,130	2,078	963	11,499
Kentucky, eastern	1,527	22,132	1,077	7,283
Maryland	---	---	81	1,180
Ohio	---	611	2,785	41,413
Pennsylvania	141	1,198	5,460	56,753
Tennessee	139	164	112	1,675
Virginia	1,827	8,059	245	1,761
West Virginia	[3] 7,371	47,472	8,402	55,194
Total[4]	[5] 12,304	81,714	[6] 19,125	176,758

1/ Reported remaining reserves on December 31, 1967.
2/ Published remaining reserves on December 31, 1964 [(4) table A-1, p. 19].
3/ Excludes ≤0.5 percent sulfur; included in total.
4/ Data may not add to totals shown because of independent rounding.
5/ Reported remaining reserve is 15 percent of published remaining reserve of ≤1.0 percent sulfur content.
6/ Reported remaining reserve is 11 percent of published remaining reserve of ≥1.1 percent sulfur content.

B. Criteria for estimating reserves.

1. Thickness of seam.

2. Overburden thickness.

The reported reserves were obtained from companies that produced 100,000 tons or more of bituminous coal during 1967. This reduced the reported reserve estimate by excluding the reserves of numerous smaller producing companies which own or lease coal land, those companies which own land but do not mine coal, individual landowners, and government-owned land. Published reserve estimates are available for some counties in which there were no operating mines in the production range of 100,000 tons or more in 1967. Consequently, it is possible that no reserves were reported for those counties. However, in other instances, reserves may have been reported in some counties with no reported production in 1967. This may occur because producing companies reported reserves in counties where they were not operating in 1967.

Larger companies generally will not attempt to mine coal less than 36 inches thick by underground methods. Young (9) reported that 88.7 percent of the coal production in the United States came from seams over 36 inches thick. Seams between 36 and 72 inches thick produced 62.5 percent, and seams over 72 inches produced 26 percent.

Approximately 50 percent of the bituminous coal in the Appalachian Region shown in published reserves is less than 28 inches thick. Less than 30 percent of the coal in this region is greater than 42 inches thick.

The overburden thickness of the coal resource in the United States is less than 1,000 feet for more than 75 percent of the coal. Most of the

coal in the United States is mined at less than 1,000 feet, although there are a few mines operating in the Appalachian Region between 1,000 and 2,000 feet deep.

The data on coal resources may be divided according to the reliability of estimates into measured, indicated, and inferred. The measured estimates are expected to be within 20 percent of the actual reserves. The producing companies report mostly measured estimates.

Probably more than 75 percent of the published reserves were not reported by the companies because the reserve estimates are in the indicated or inferred category. The companies probably reported less than 50 percent of the measured reserves because they only reported reserves they expected to mine in the foreseeable future, that is seams over 28 inches thick and under less than 1,000 feet of overburden.

The net limiting effect of collecting coal reserve data from selected producing companies was to reduce the reported reserves to approximately 12 percent of the published reserves (table 3). This agrees favorably with the U.S. Geological Survey national estimate of 7 percent for remaining coal reserves over 28 inches thick and less than 1,000 feet deep (page 90, (1)).

Availability of coal for mining is affected in many ways. Natural and man-made surface features such as rivers, lakes, reservoirs, highways, railroads, oil and gas wells, and various structures segregate the coals from mining. State regulations prohibiting coal mining under State parks, municipalities, homes, and strip mining on slopes over a specified grade also restrict coal availability.

The remaining coal reserves reported to the U.S. Bureau of Mines on Form 6-1418-X are the reserves the producing companies expect to mine in the foreseeable future. These reserves should not be construed to be the total reserves which might be mined in the Appalachian Region.

Total Remaining Reserves

Total remaining reserves reported were 31.4 billion tons. Those reserves associated with mines operating in 1967 totaled 34 percent (10.6 billion tons), those associated with mines scheduled to operate by 1973 totaled 15 percent (4.6 billion tons), and those associated with coal lands not assigned to active mines totaled 51 percent (16.2 billion tons) (table 1). Thus, a large percentage of reported remaining reserves are not assigned to operating mines.

Commercial reserves totaled 40 percent, captive 9 percent, and "other" 52 percent (table 2). The term "other" is used to distinguish reserves reported as neither commercial nor captive. When the reserves are assigned to active mines, it will be possible to classify them as commercial or captive.

Location of the reported remaining reserves is important (figure 3 and table 1). West Virginia contains one-half of these reserves followed by Pennsylvania (18 percent), Ohio (9 percent), eastern Kentucky (8 percent), Alabama (7 percent), Virginia (7 percent), Tennessee (1 percent), and Maryland (less than 0.5 percent).

Ten of the 11 counties which reported remaining reserves greater than 1 billion tons were: Jefferson (Alabama); Belmont (Ohio); Greene and Washington (Pennsylvania); and Boone, Kanawha, Logan, Marion, Monongalia,

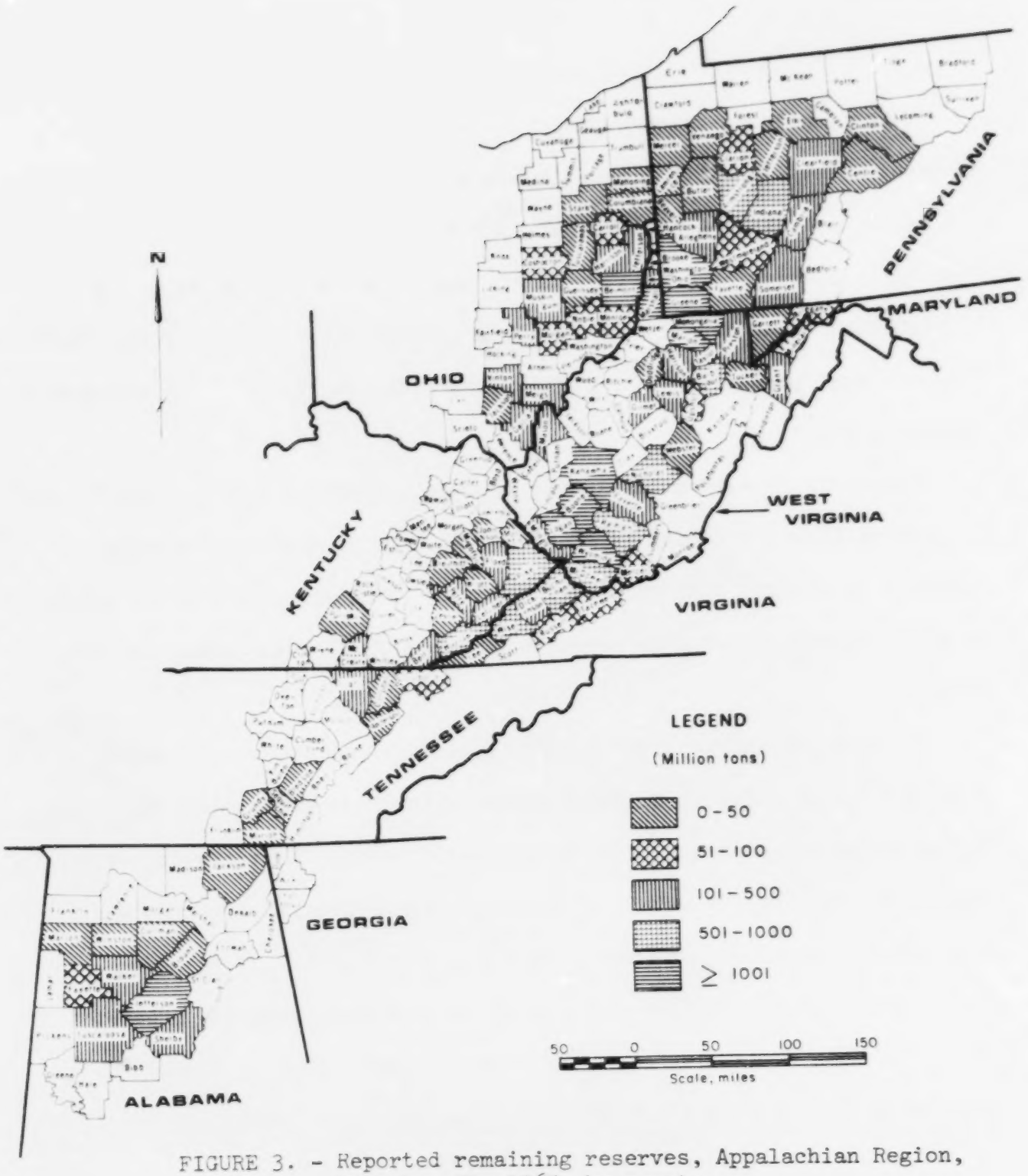


FIGURE 3. - Reported remaining reserves, Appalachian Region, December 31, 1967, by county.

and Wyoming (West Virginia). The 10 counties also were among the leaders in reported coal produced in 1967, each reporting more than 5 million tons. The one county not mentioned has been withheld to avoid disclosing individual company data.

Sulfur content is significant in the consideration of the reported remaining reserves. Of the 12.3 billion tons that contain 1.0 percent or less sulfur, about 60 percent is in West Virginia, followed by 15 percent in Virginia, 12 percent in eastern Kentucky, and 9 percent in Alabama. The percentage these reserves comprise of the total reserves within each State is as follows: West Virginia, 47 percent; Virginia, 88 percent; eastern Kentucky, 59 percent; and Alabama, 51 percent. Percentages in Alabama and West Virginia exclude reserves containing less than 0.6 percent sulfur in order to conceal individual company confidential data. These States are the most important sources in the region for present and future remaining reserves of bituminous coal with this sulfur content. These reserves are concentrated in 50 counties.

A greater part of the reported remaining reserves, 19.1 billion tons, contain more than 1.0 percent sulfur.

Pennsylvania, Alabama, eastern Kentucky, and West Virginia, in decreasing order, contain most of the remaining reserves with 1.1 through 2.0 percent sulfur.

The apparently anomalous bar graphs for West Virginia and Tennessee (figure 4) may be due to the manner in which the respondents reported information, combined with the divisions in the sulfur concentrations. Some of the respondents did not report the sulfur concentration to the nearest tenth of a percent. This created some uncertainity as to whether

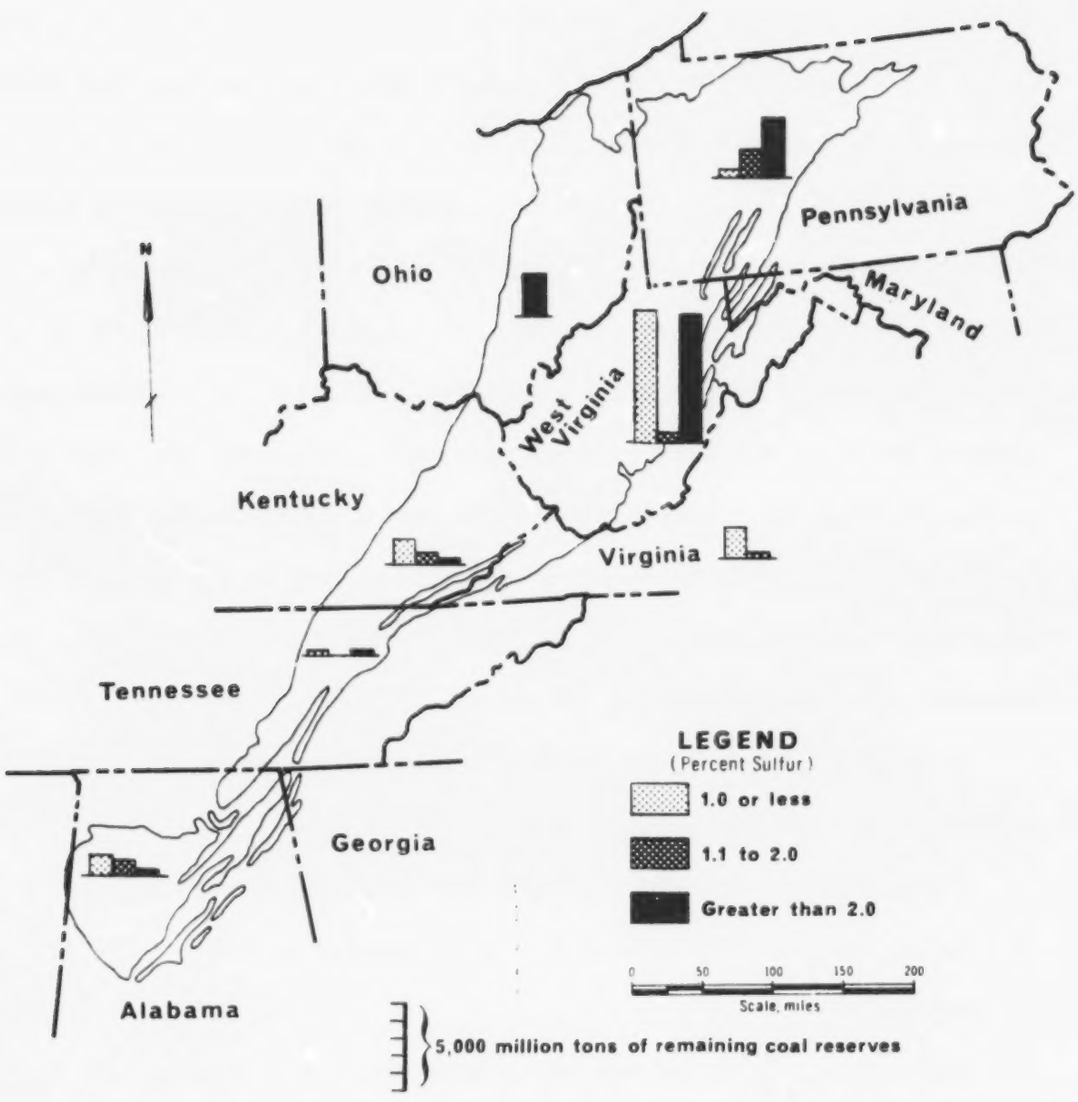


FIGURE 4. - Reported remaining reserves, Appalachian Region, December 31, 1967, by State.

the sulfur concentration might be a tenth of a percent higher, and therefore belong in the next higher category, especially in the range of 1.1 to 2.0 percent sulfur.

Commercial Remaining Reserves

Commercial remaining reserves, those reported remaining reserves available for sale on the open market, amount to 12.5 billion tons or 40 percent of the total remaining reserves (table 2). Two-thirds of these reserves are assigned to active mining operations.

West Virginia leads the eight States with a reported 52 percent (6 billion tons) of commercial remaining reserves; Pennsylvania reported 16 percent (2 billion tons), and eastern Kentucky, Ohio, and Virginia each reported about 10 percent (more than 1 billion tons) (table 1).

The 32 counties reporting more than 100 million tons of commercial remaining reserves (figure 5) include Harlan, Letcher, Perry, and Pike (eastern Kentucky); Belmont, Harrison, Jefferson, and Perry (Ohio); Armstrong, Cambria, Clearfield, Indiana, Somerset, and Washington (Pennsylvania); Buchanan, Dickenson, and Wise (Virginia); and Boone, Fayette, Grant, Harrison, Kanawha, Logan, McDowell, Marion, Marshall, Mason, Monongalia, Nicholas, Ohio, Raleigh, and Wyoming (West Virginia). Nineteen of these 32 counties contain reserves with 1.0 percent or less sulfur.

Captive Remaining Reserves

Captive remaining reserves, those reported remaining reserves available mostly for owner consumption, amount to 2.7 billion tons or 9 percent of the total remaining reserves (table 2). Fifty-five percent of these reserves contain 1.0 percent or less sulfur.

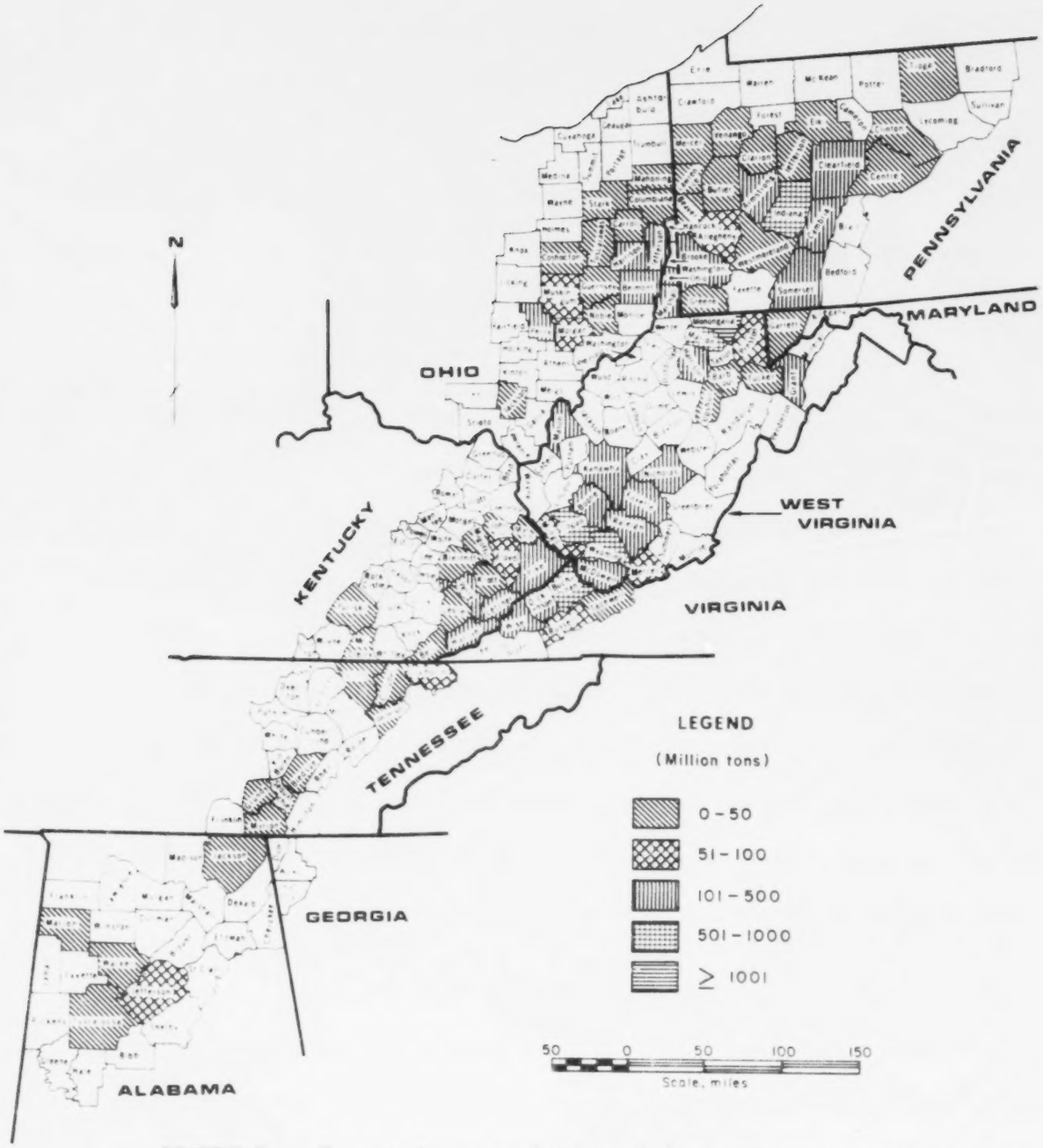


FIGURE 5. - Reported commercial remaining reserves, Appalachian Region, December 31, 1967, by county.

West Virginia leads the Appalachian States with captive remaining reserves (figure 6); Pennsylvania is second; Alabama is a distant third; eastern Kentucky, fourth; and Ohio, fifth.

The eight counties with 100 million tons or more of captive remaining reserves are Jefferson (Alabama); Pike (eastern Kentucky); Cambria, Greene, and Washington (Pennsylvania); and Kanawha, McDowell, and Wyoming (West Virginia) (figure 6). Of these counties, Jefferson, Pike, McDowell, Kanawha, and Wyoming also reported remaining reserves of coal with 1.0 percent or less sulfur.

Total Recoverable Reserves

The total reported recoverable coal reserves is 13.4 billion tons, or 43 percent of the remaining reserves (table 1). West Virginia leads in reported recoverable reserves with 60 percent (8 billion tons); Pennsylvania is second with 17 percent (2 billion); and eastern Kentucky, third with 9 percent (1 billion). The five remaining States have a cumulative total of 15 percent and each has less than 1 billion tons.

At 1967 f.o.b. prices, 5.7 billion tons of bituminous coal was reported as recoverable. An additional 7.7 billion tons could be recovered at more than $2.00 per ton above 1967 prices (table 1). Recent increases in both prices and demand for coal at all sulfur levels may affect these price categories. Reserves estimated available at 1967 prices undoubtedly are not available in 1971 without price increases. Therefore, recoverable reserves estimated available by the reporting companies at an increase of more than $2.00 per ton above 1967 prices are the total reported recoverable reserves.

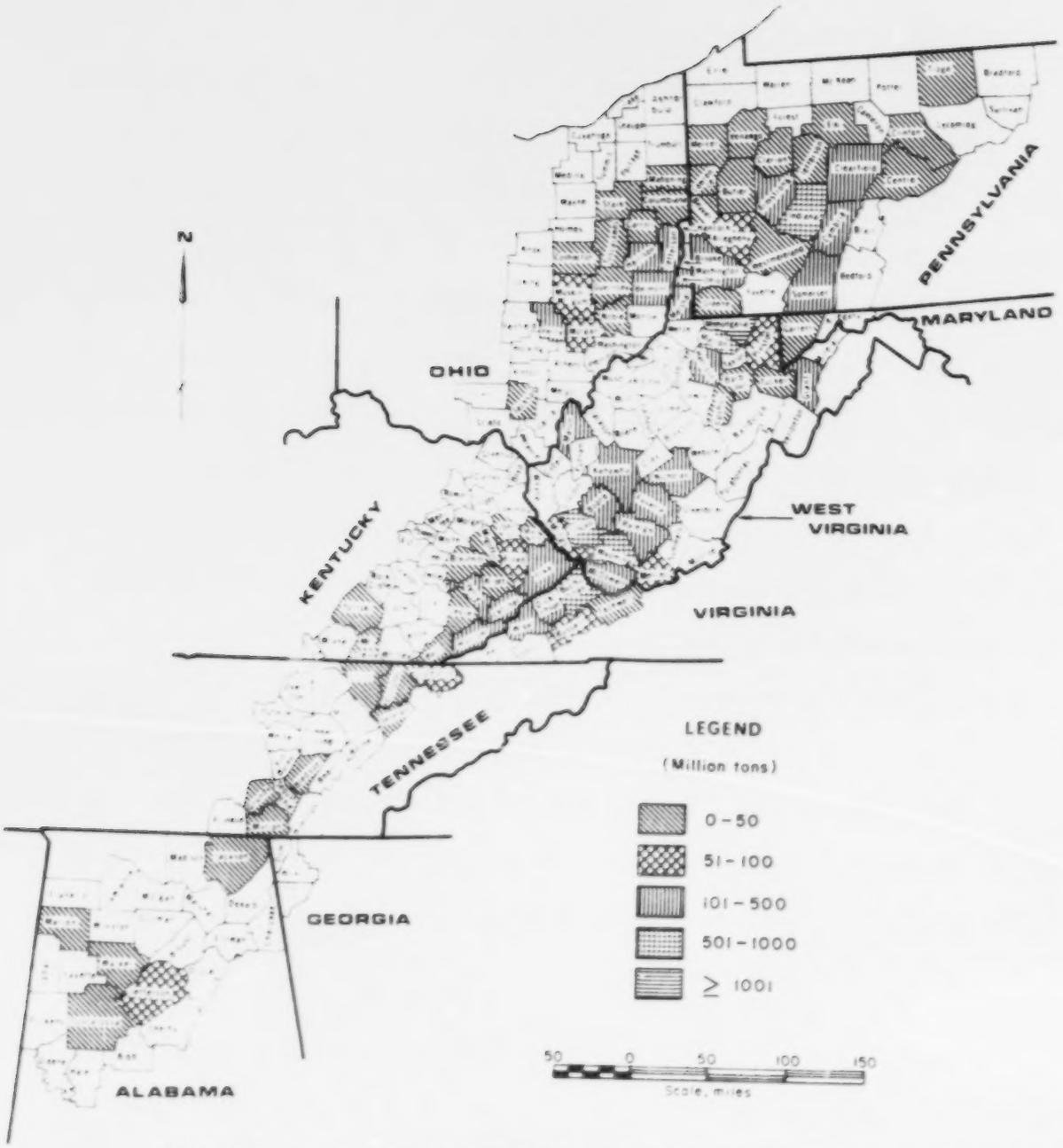


FIGURE 5. - Reported commercial remaining reserves, Appalachian Region, December 31, 1967, by county.

Of the 12.3 billion tons of remaining reserves of coal with 1.0 percent or less sulfur, only 4.5 billion tons was reported recoverable. Seventy-two percent of these recoverable reserves were reported in West Virginia, 13 percent in eastern Kentucky, and 11 percent in Virginia. West Virginia reported more coal with 1.0 percent or less sulfur than the other seven States combined (table 1).

One county reported more than 100 million tons of recoverable reserves in Alabama, four counties in eastern Kentucky, none in Maryland or Tennessee, two in Ohio, six in Pennsylvania, three in Virginia, and 18 in West Virginia. Boone and Marion Counties, West Virginia, each reported more than 1 billion tons of recoverable reserves.

The 0.6 through 1.0 percent sulfur category contained 33 percent of the reported total recoverable reserves; 66 percent of these reserves contained more than 1.0 percent sulfur. Reserves with 0.5 percent or less sulfur were negligible (less than one percent). For Alabama, 22 percent of the reported recoverable reserves of bituminous coal contains 1.0 percent or less sulfur; and 49 percent for eastern Kentucky, 2 percent for Pennsylvania; 90 percent for Virginia; and 41 percent for West Virginia. Two counties (Boone and Marion) in West Virginia reported more than 1 billion tons of recoverable coal reserves. Those in Boone, in large part, contain 1.0 percent or less sulfur, while those in Marion contain more than 1.0 percent sulfur.

The total recoverable tonnage is only 43 percent of the reported remaining reserves (table 1). This is below the national average for coal mine recovery. It may be due to the fact that a few large companies with

captive mines did not report recoverable reserves by price level; instead they reported only remaining reserves. This is discussed further in the section on Captive Recoverable Reserves. Only for West Virginia and Tennessee did the percentage of recoverable reserves in table 1 equal the national average for recovery. The remaining States show recoverable reserves which are 6 to 45 percent of the remaining reserves.

The 13.4 billion tons of reported total recoverable reserves are further divided into commercial, captive, and other (table 2); 48 percent (6.4 billion tons) are commercial, only 5 percent (701 million tons) are captive, but 47 percent (6.3 billion tons) are "other" (not determined as captive or commercial).

About five times more remaining reserves classified as commercial were reported than captive remaining reserves. But nine times more commercial than captive reserves were reported as recoverable at more than $2.00 per ton above 1967 prices. About 1 billion tons of captive remaining reserves contain 1.0 percent or less sulfur.

Commercial Recoverable Reserves

Those recoverable reserves available for sale on the open market, are 6.4 billion tons or 48 percent of the total recoverable reserves (table 2). Approximately 37 percent (2.3 billion tons) of commercial recoverable reserves contain 1.0 percent or less suflur. This quantity is nine times the reported total annual production from the Appalachian Region. On the other hand, approximately 63 percent (4.1 billion tons) contains more than 1.0 percent sulfur; this tonnage is 15 times the reported annual production from the region.

The reported commercial recoverable reserves are located as follows: 54 percent in West Virginia, 16 percent in Pennsylvania, 12 percent in eastern Kentucky, and 7 percent in Virginia.

Captive Recoverable Reserves

Captive recoverable reserves, those recoverable reserves available mostly for owner consumption, comprise only 11 percent (701 million tons) of the reported total recoverable reserves and only 2 percent of the total remaining reserves. This unusually low recovery percentage resulted from the fact that a few major captive operators did not report recoverable coal by price increments (table 2). A more realistic estimate would be 1.3 billion tons of captive recoverable reserves based on a 50 percent recovery factor. Even with this adjusted estimate, captive recoverable reserves are the smallest of the major reported reserve categories.

About 65 percent of the captive recoverable reserves contain 1.0 percent or less sulfur.

The major distribution of the reported captive recoverable reserves by States is 66 percent in West Virginia, 13 percent in Alabama, and 12 percent in Pennsylvania.

Only 3 counties in the Appalachian Region contain more than 50 million tons of captive recoverable reserves with 1.0 percent or less sulfur.

Ownership of Coal Reserves

Ownership of coal reserves in the Appalachian coal region can be divided into two major categories: Governmental and private. Government ownership can be divided into Federal, State, county, and municipal. Lands owned by the Federal Government in the Appalachian Region are controlled and supervised by many different agencies, the more important of which, on a land ownership basis, are National Forest Service, National Park Service, Fish and Wildlife Service, Public Health Service, Corps of Engineers, Atomic Energy Commission, Tennessee Valley Authority, Army, Air Force, and Navy. State-owned lands are parks, recreation areas, forests, farms and school lands. County-owned lands include parks, recreation areas, and airports. Municipal lands include parks, recreation areas, airports, and reservoirs.

Private ownership of coal lands is varied. Ownership of available coal is vested in mining companies, lumber companies, landholding companies, railroads, and private individuals. Ownership of coal may be fee (all rights), or in ownership of the coal rights only. Lease contracts for the coal constitute a form of limited ownership.

Ownership of coal reserves has not been compiled into a form readily available for use. To compile the basic data on surface and coal ownership, it would be necessary to consult numerous possible sources of information.

Sources of data on governmental land and coal ownership are Federal, State, county, and municipal agencies. Most of these agencies have the lands under their supervision cataloged and are able to describe the acreage and the rights owned. It is necessary to know the rights-of-ownership

because conditions of ownership, combined with Federal and State regulations may preclude coal mining under such lands.

Data on private ownership can be acquired by checking county ownership records. These records contain the names, addresses, and rights of all owners of large acreages of coal lands who also own the coal rights. Information on coal ownership may be so complex as to be unattainable without the cooperation of the individual owners.

The following land ownership information was extracted from Public Land Statistics 1969 (8) and from the Statistical Abstract of the United States 1969 (7). Using these statistics the lands within the Appalachian coal region cannot be segregated from the rest of the land in each of the States. The relationship between the land surface ownership and the coal ownership cannot be determined. Ratios of surface ownerships for each State as a whole may be applicable to the lands within the Appalachian coal region. Federal ownership of lands in the States of the Appalachian Region range from 1 percent to 8 percent and average a little over 4 percent (table 4). From this, it may be assumed that the Federal land ownership in the Appalachian coal region would average about 4 percent. The same reasoning is applicable to State and private ownership within the Appalachian coal region.

Data on some State lands supervised by the West Virginia Department of Natural Resources have been compiled to show the distribution of coal ownership (table 5). The availability of the coal for mining is shown in each of the land categories. Data on the extent of the coal reserves was not available (figure 7).

TABLE 4. - Surface ownership in the Appalachian coal region

(acres)

State	Ownership 1/			Total land	Inland waters	Total surface
	Federal	State	Private			
Alabama	1,097,319	1,930,480	29,650,601	32,678,400	351,360	33,024,760
Percent of total area	3.32	5.85	89.77	98.94	1.06	100.0
Kentucky	1,230,725	586,103	23,695,492	25,512,320	340,480	25,852,800
Percent of total area	4.76	2.27	91.65	98.68	1.32	100.0
Maryland	189,824	595,126	5,534,410	6,319,360	449,920	6,769,280
Percent of total area	2.80	8.75	81.76	93.35	6.65	100.0
Ohio	263,016	2,276,331	23,682,733	26,222,080	160,000	26,382,080
Percent of total area	1.00	8.63	89.76	99.39	0.61	100.0
Pennsylvania	597,742	6,672,123	21,534,615	28,804,480	208,640	29,013,120
Percent of total area	2.06	23.00	74.22	99.28	0.72	100.0
Tennessee	1,699,448	1,439,263	23,588,969	26,727,680	308,480	27,036,160
Percent of total area	6.29	5.32	87.25	98.86	1.14	100.0
Virginia	2,192,118	630,452	22,673,750	25,496,320	662,400	26,158,720
Percent of total area	8.38	2.41	86.68	97.47	2.53	100.0
West Virginia	987,810	576,976	13,845,774	15,410,560	65,280	15,475,840
Percent of total area	6.38	3.73	89.47	99.58	0.42	100.0
Totals	8,258,002	14,706,854	164,206,344	187,171,200	2,546,560	189,717,760
Percent of total area	4.35	7.75	86.56	98.66	1.34	100.0

1/ May not relate to coal ownership.

Sources: Public Land Statistics and Statistical Abstract of the United States.

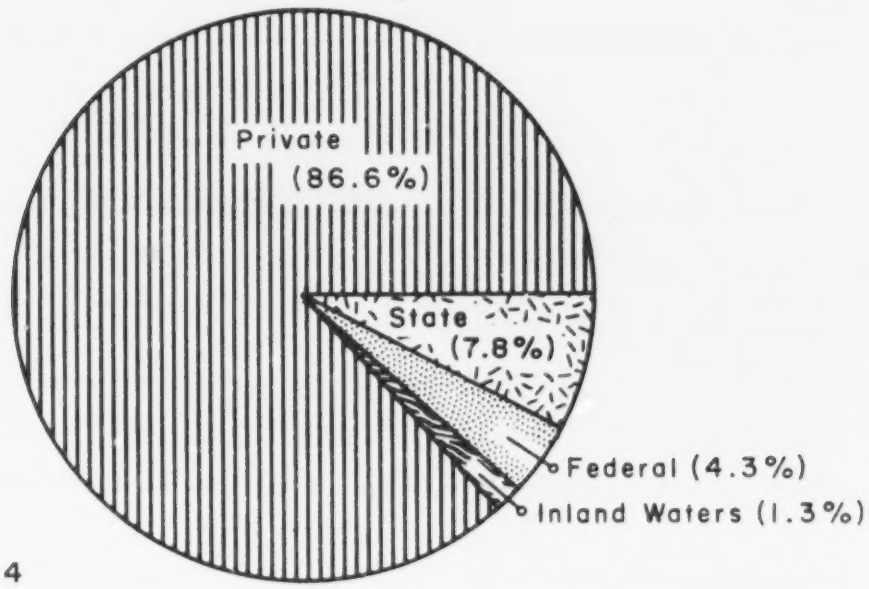
TABLE 5. - Distribution of coal ownership in some West Virginia State lands under supervision of the State Department of Natural Resources

Type of area	Acres of surface owned	Percent of coal not available for mining				Percent of privately owned coal available for mining
		State ownership	Federal ownership	Private ownership	Total	
State Parks	33,472	47.5	0.0	52.2	100.0	0.0
PHFA 1/	56,220	25.0	14.1	0.0	39.1	60.9
State Forests	51,152	82.9	0.0	0.0	82.9	17.1
Other 2/	3,011	3.2	81.4	0.0	84.6	15.4
Total	143,855	50.4	7.2	12.2	69.8	30.2

1/ Public Hunting and Fishing Areas.
2/ Includes fish hatcheries, game farms and refuges, and tree nurseries.

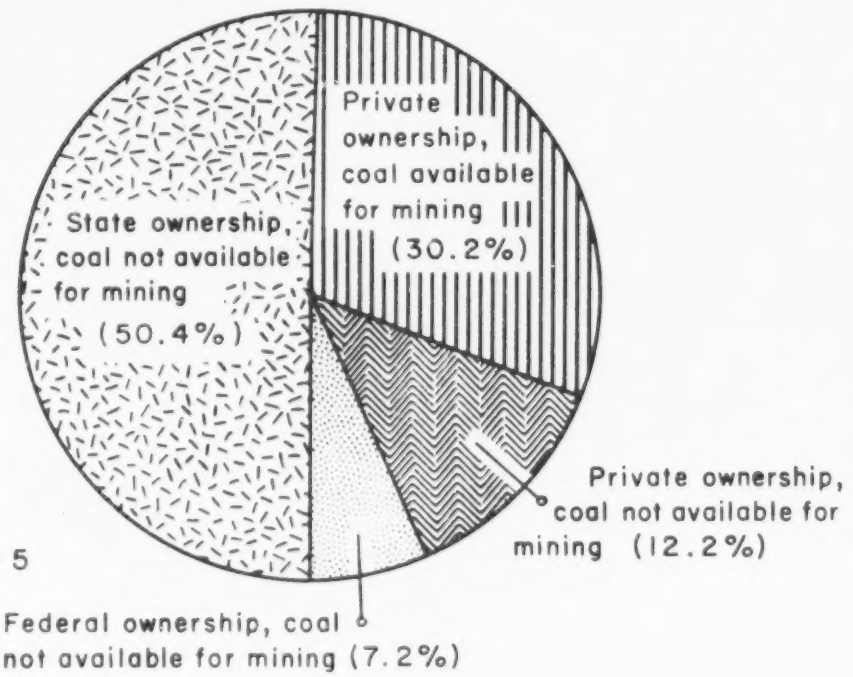
Source: West Virginia Department of Natural Resources.

A. - Land surface ownership in the bituminous coal producing States of the Appalachian Region.



Source: TABLE - 4

B. - Coal ownership in West Virginia State-owned lands under the supervision of the Department of Natural Resources.


Private ownership, coal available for mining (30.2%)
State ownership, coal not available for mining (50.4%)
Private ownership, coal not available for mining (12.2%)
Federal ownership, coal not available for mining (7.2%)

Source: TABLE - 5

FIGURE 7. - Ownership of surface land areas and coal ownership in the Appalachian Region.

The magnitude of the coal reserves that could be in these State lands can be illustrated if a supposition is made that each of the State-owned lands contains a minable seam of coal 3 feet thick. The total remaining reserve would then be 777 million tons of coal. Of this hypothetical reserve, 542 million tons would be reserved from mining and 235 million tons could be mined.

PRODUCTION AND CONSUMER USES

Production

Reported production of bituminous coal in 1967 by companies producing 100,000 tons or more in the Appalachian Region amounted to 266 million tons. This represents 68 percent of the total production from the Appalachian Region (table 6). The distribution of production by State is as follows: West Virginia reported 43 percent, followed by Pennsylvania with 21 percent; Ohio, 13 percent; eastern Kentucky, 9 percent; Virginia, 8 percent; Alabama, 4 percent; and Tennessee and Maryland accounted for 1 percent (figure 8).

One hundred and fifteen million tons of 1.0 percent or less sulfur coal was produced in 44 counties of the Appalachian Region (table 7). Ninety-five percent of the 115 million tons was produced in 23 of the 44 counties. About 57 percent (65 million tons) was a product of 10 counties in West Virginia. The 1967 reported production in the Appalachian Region of coal with less than 1.0 percent sulfur content was less than one percent of the 12 billion tons of reported remaining reserves of less than 1.0 percent sulfur.

One county in each of Alabama, Kentucky, Tennessee, Virginia, and West Virginia with reserves of 1.0 percent or less sulfur reported no production of coal at this sulfur level. The total available reserves from these counties were 124 million tons. Pennsylvania reported remaining reserves of 60 million tons in 6 counties which reported no production in 1967 (table 7).

TABLE 6. - Production of bituminous coal, Appalachian Region, 1967, by State

(thousand tons)

State	Production reported by producers of 100,000 tons or more (Form 6-1418-X)	Production reported by producers of 1,000 tons or more (Form 6-1401-A)
Alabama	11,417	15,486
Kentucky, eastern	23,437	53,904
Maryland	641	1,305
Ohio	35,449	46,014
Pennsylvania	56,511	79,412
Tennessee	3,026	6,832
Virginia	20,197	36,721
West Virginia	115,232	153,749
Total	265,910	393,423

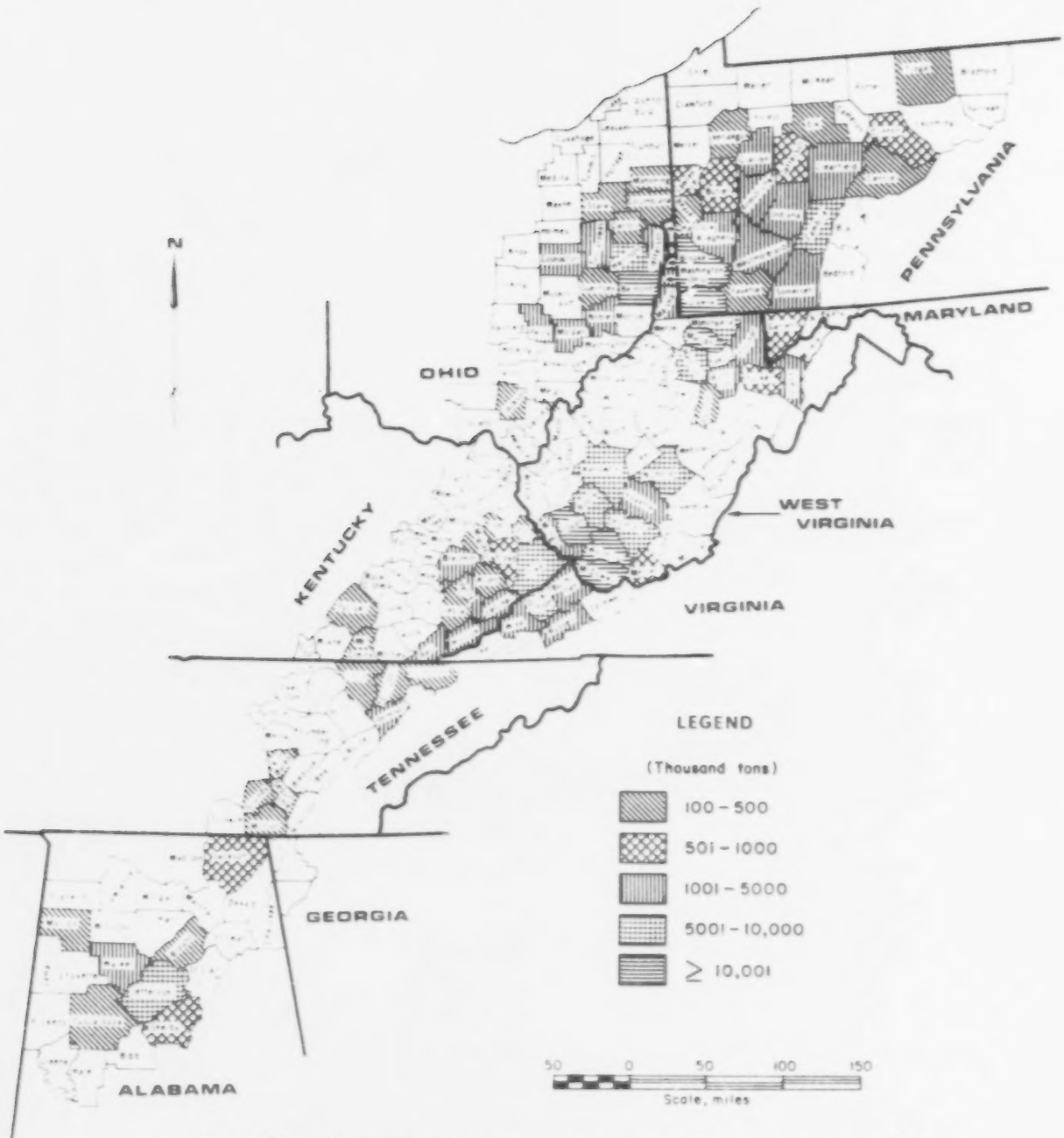


FIGURE 8. - Reported total production of bituminous coal, Appalachian Region, December 31, 1967, by county.

TABLE 7. - Production and reserves of coal in the Appalachian Region with 1.0 percent or less sulfur content, by counties

(Thousand short tons)

State	County	Production 1967 1/	Remaining reserves, December 31, 1967
Alabama	Blount	171	1,500
	Cullman	---	W
	Jackson	W	W
	Jefferson	2,833	W
	Marion	12	(2)
	Shelby	W	W
	Tuscaloosa	W	W
	Walker	W	144,980
	Undistributed	2,943	983,880
	Total 3/	5,958	4/ 1,130,360
Kentucky	Bell	W	W
	Breathitt	1,098	W
	Floyd	W	W
	Harlan	5/ 1,257	W
	Johnson	W	W
	Knott	345	W
	Leslie	491	W
	Letcher	2,335	W
	Magoffin	W	W
	McCreary	---	W
	Perry	W	W
	Pike	6,154	545,930
	Pulaski	W	(2)
	Undistributed	5,994	981,160
	Total 3/	17,676	1,527,090
Pennsylvania	Allegheny	W	(2)
	Cambria	W	W
	Centre	---	W
	Clarion	---	W
	Clearfield	W	W
	Clinton	---	W
	Fayette	---	W
	Indiana	---	W
	Mercer	---	310
	Somerset	W	W
	Tioga	W	(2)
	Westmoreland	W	(2)
	Undistributed	7,475	140,450
	Total 3/	7,475	140,760

TABLE 7. - Production and reserves of coal in the Appalachian Region with 1.0 percent or less sulfur content, by counties - Continued

(Thousand short tons)

State	County	Production 1967 1/	Remaining reserves, December 31, 1967
Tennessee	Anderson	W	W
	Campbell	W	W
	Claiborne	W	W
	Grundy	W	W
	Marion	W	W
	Sequatchie	---	W
	Undistributed	1,077	138,950
	Total 3/	1,077	138,950
Virginia	Buchanan	W	877,010
	Dickenson	W	W
	Russell	2,207	61,000
	Tazewell	---	W
	Wise	4,142	436,340
	Undistributed	11,335	452,480
	Total 3/	17,684	1,826,830
West Virginia	Boone	5,374	1,770,060
	Fayette	2,957	118,070
	Kanawha	4,720	1,010,130
	Logan	7,521	1,102,890
	McDowell	14,692	W
	Mercer	W	W
	Mingo	W	W
	Nicholas	5/ 5,660	W
	Raleigh	6,480	447,850
	Webster	---	(6)
	Wyoming	13,581	1,345,970
	Undistributed	4,220	1,575,630
	Total 3/	65,206	4/ 7,370,600
Grand Total 3/		115,076	12,304,110

W Withheld to avoid disclosing individual company confidential data.
1/ Reported on Form 6-1418-X.
2/ Reserves of ≤1.0 percent sulfur content not reported.
3/ Data may not add to totals shown because of independent rounding.
4/ 0.6-1.0 percent sulfur only; ≤0.5 percent sulfur included in "Grand Total."
5/ 0.6-1.0 percent sulfur only; ≤0.5 percent sulfur included in "Undistributed."
6/ ≤0.5 percent sulfur only; included in "Grand Total."

Most of the production of 1.0 percent or less sulfur from available reserves probably will come from the 23 large producing counties in 1967.

Thirteen billion tons of recoverable reserves were reported on the questionnaire (Form 6-1418-X). At the 1967 consumption rate, these reserves will last 49 years (table 8). However, only 4.5 billion of the recoverable reserves are 1.0 percent or less in sulfur content. At the 1967 rate of consumption, the supply would last only 17 years if all consumers were to use coal containing 1.0 percent or less sulfur.

Published sources of coal production data sometimes divide the data into the Federal Bituminous Coal Producing Districts shown in figure 9.

Consumer Uses

The reported (Form 6-1418-X) consumption pattern of bituminous coal by sulfur content from the Appalachian Region is reflected in tables 9 and 10 and figure 10. From a reported supply of 266 million tons, electric utilities consumed the greatest share, some 117 million tons (44 percent). Coke plants utilized 81 million tons (30 percent). Coal requirements for manufacturing and other industrial uses totaled 44 million tons or 17 percent, and exports 9 percent.

In 1967, the electric utilities market consumed 104 million tons of commercially produced coal and 13 million tons of captive coal. One hundred and seventeen million tons represented 44 percent of the demand for fuel by the Nation's 940 utility plants. There is a close similarity between the prices of commercial and captive coal of the same quality. This similarity suggests that utilities invest in and operate mines because of the long-term

TABLE 8. - Availability of bituminous coal, Appalachian Region, December 31, 1967, by sulfur content

(Million tons)

Sulfur content (percent)	1967 reported production[1/]	Reported recoverable reserves	Projected availability (years)
≤0.3	2/ 1	---	---
≤0.5	8	101	13
0.6-1.0	107	4,448	42
1.1-1.5	36	947	26
1.6-2.0	20	776	39
2.1-3.0	56	2,660	48
≥3.1	38	4,128	109
Total	3/ 265	4/ 13,060	5/ 49

1/ Reported on Form 6-1418-X.
2/ Less than 0.5 million tons.
3/ Excludes 1.7 million tons reported with no sulfur data.
4/ Excludes 1 billion tons reported with no sulfur data.
5/ Weighted average.

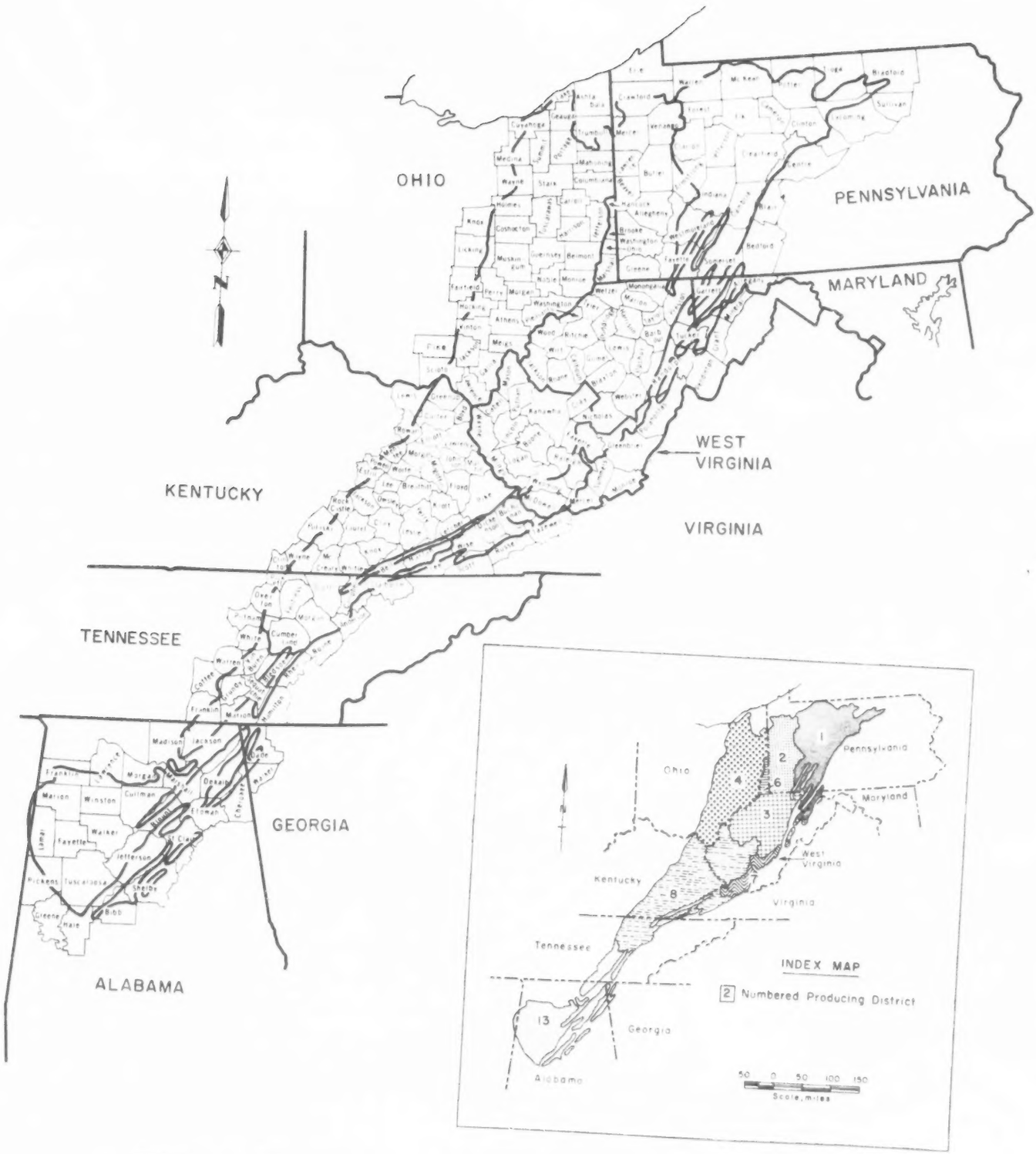


FIGURE 9. - Federal bituminous coal producing districts of the Appalachian Region.

TABLE 9. - Reported production of commercial and captive bituminous coal, Appalachian Region, 1967, by consumer use and sulfur content

(Thousand short tons)

Status	Sulfur content (percent)	Electric utilities	Coke plants	Industrial, retail, and other	Export market	Total shipments[1]
Commercial[2]	≤0.3	---	---	(3)	---	(3)
	≤0.5	W	W	W	W	W
	0.6-1.0	22,765	[4] 21,067	W	W	73,773
	1.1-1.5	5,597	4,221	6,257	993	17,068
	1.6-2.0	7,853	W	[5] 2,873	W	12,208
	2.1-3.0	W	W	[5] 8,533	3,663	53,405
	≥3.1	25,496	W	5,985	---	W
	(6)	726	---	713	W	W
	Subtotal[1]	103,907	[4] 29,822	[5] 36,695	23,141	193,565
Percent of individual consumer total		89	37	83	96	73
Captive[2]	≤0.3	---	---	---	---	---
	≤0.5	W	W	W	---	W
	0.6-1.0	2,519	25,486	W	W	33,373
	1.1-1.5	1,030	15,760	1,656	---	18,446
	1.6-2.0	1,198	W	W	W	7,711
	2.1-3.0	W	---	W	---	2,597
	≥3.1	5,633	---	W	---	W
	(6)	---	W	---	---	W
	Subtotal[1]	12,822	51,292	7,257	975	72,343
Percent of individual consumer total		11	63	17	4	27

TABLE 9. - Reported production of commercial and captive bituminous coal, Appalachian Region, 1967, by consumer use and sulfur content - Continued

(Thousand short tons)

Status	Sulfur content (percent)	Electric utilities	Coke plants	Industrial, retail, and other	Export market	Total shipments[1]
Commercial and Captive	≤0.3	---	---	(3)	---	(3)
	≤0.5	474	6,708	W	W	7,932
	0.6-1.0	25,284	[4]46,553	[5]16,441	18,868	107,146
	1.1-1.5	6,627	19,981	7,913	993	35,514
	1.6-2.0	9,051	7,305	W	W	19,919
	2.1-3.0	43,438	W	W	3,663	56,002
	≥3.0	31,129	W	W	---	37,656
	(6)	726	W	713	W	1,742
	TOTAL[1]	116,729	[4]81,112	[5]43,949	24,115	265,910
Percent of individual consumer total		44	30	17	9	100

W Withheld to avoid disclosing individual company confidential data.
1/ Data may not add to totals shown because of independent round.
2/ Production from individual mines was reported as commercial if over 50 percent was commercially produced, and captive if over 50 percent was captive.
3/ Included in ≤0.5 percent sulfur content.
4/ Excludes some bituminous coal used for coke; included with "Industrial, retail, and other.
5/ Includes some bituminous coal used for coke.
6/ Sulfur content not reported.

TABLE 10. - Reported consumer uses of coal by weighted average sulfur content, produced by selected companies, Appalachian Region, 1967

(Thousand short tons)

State	Electric utilities			Coke plants			Industrial and retail			Export market			Other			Total 1/	
	Quantity	Sulfur range	Average sulfur	Quantity	Sulfur range	Average sulfur	Quantity	Sulfur range	Average sulfur	Quantity	Sulfur range	Average sulfur	Quantity	Sulfur range	Average sulfur	Quantity	Average sulfur
Ala.	5,823	0.7 - 2.3	1.5	4,199	0.6 - 1.5	1.0	1,393	0.9 - 1.4	1.3	-	-	-	-	-	-	11,417	1.3
Ky.East	10,140	0.5 - 4.0	1.3	6,963	0.5 - 1.4	0.6	5,684	0.5 - 2.0	0.9	W	0.5 - 0.9	0.6	W	0.5 - 1.3	0.7	23,437	1.0
Md.	486	2.5 - 3.3	2.7	-	-	-	135	3.0	3.0	-	-	-	20	3.0	3.0	641	2.8
Ohio	26,681	1.7 - 5.5	3.7	(2)	1.4 - 2.8	1.8	7,724	1.4 - 5.0	3.4	-	-	-	3/1,043	2.5 - 4.6	3.6	35,449	3.7
Pa.Bit.	20,000	0.8 - 4.6	2.4	27,721	0.9 - 3.5	1.3	6,162	0.2 - 3.7	1.9	W	1.0 - 3.0	1.7	W	1.0 - 3.5	2.2	56,511	1.8
Tenn.	2,345	1.0 - 4.0	2.1	-	-	-	(2)	1.0 - 3.3	1.3	-	-	-	4/680	0.7	0.7	3,026	1.9
Va.	7,572	0.5 - 6.0	1.0	6,152	0.5 - 0.9	0.6	1,831	0.5 - 6.0	1.1	W	0.5 - 2.0	0.8	W	0.5 - 1.5	0.8	20,197	0.9
W. Va.	43,682	0.5 - 4.2	2.3	36,077	0.5 - 3.3	0.8	15,453	0.5 - 4.2	1.4	17,700	0.5 - 3.0	1.0	2,320	0.4 - 3.3	1.2	115,232	1.5
Total	116,729		2.4	5/81,112		1.0	5/38,382		1.8	24,115		1.0	5,567		1.7	265,910	1.8

W - Withheld to avoid disclosing individual company confidential data.
1/ Data may not add to totals shown because of independent rounding.
2/ Withheld to avoid disclosing individual company confidential data; included with "Other".
3/ Includes coke and other uses.
4/ Includes industrial, retail and other uses.
5/ Excludes data indicated by footnote 2/.

Source: Data obtained from a special canvass of coal producers of 100,000 tons or more in 1967.

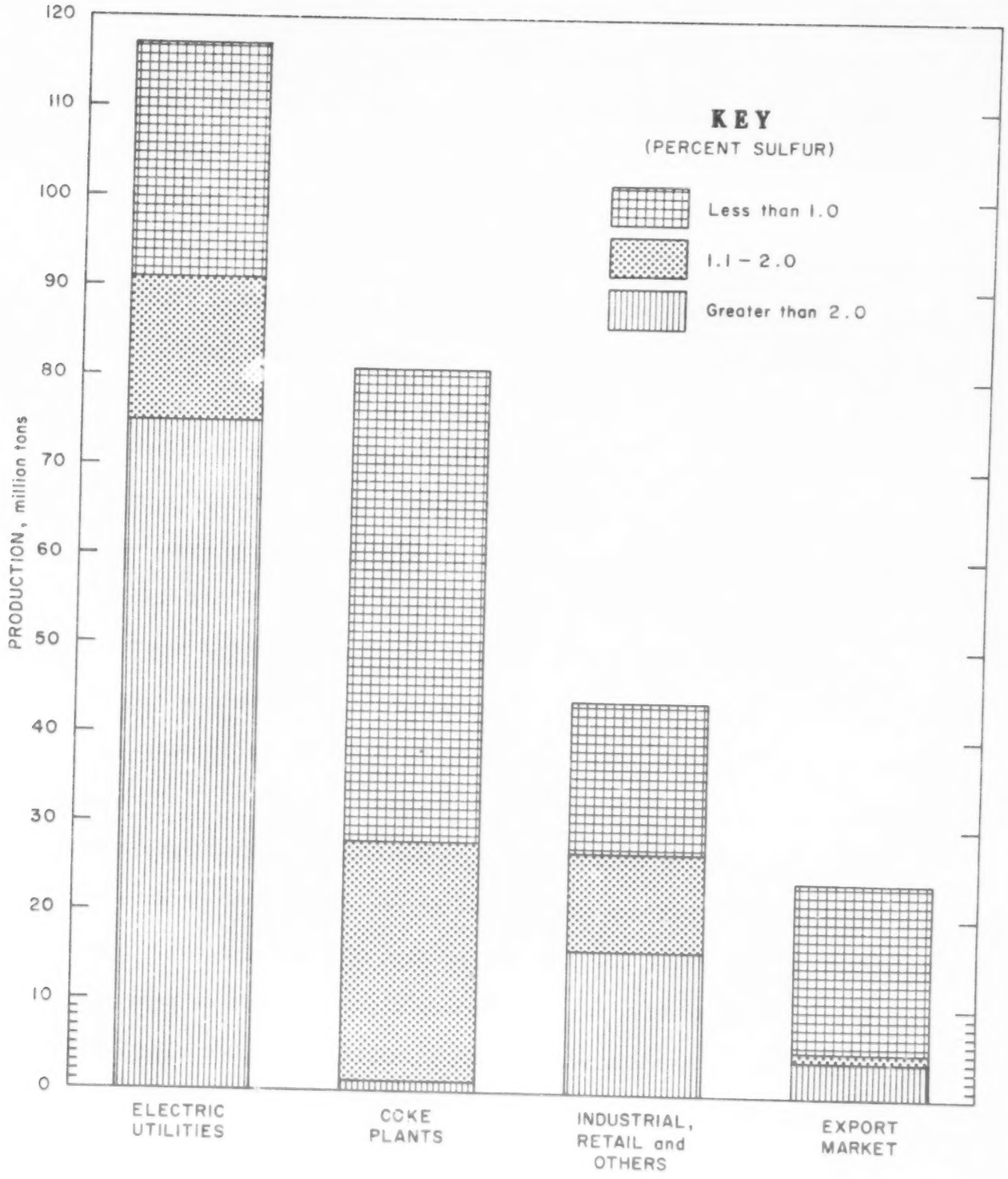


FIGURE 10. - Bituminous coal production, Appalachian Region, 1967, by sulfur content and consumer use.

supply assurance. Most of the coal consumed by electric utilities in 1967 contained a weighted average sulfur content of 2.4 percent (table 10).

Commercial producers supplied electric utilities with 23 million tons of coal containing greater than 3.0 percent sulfur and at prices ranging from about $3.50 to $5.50 per ton. Slightly less than one-half of the total commercial supply for utilities, 46 million tons, contained 1.6 to 3.0 percent sulfur. Captive mines supplied slightly less than 4 million tons of the same quality coal, or about 28 percent of the total.

Ninety-seven percent (45 million tons) of the commercial coal reported by price in the 1.6 to 3.0 percent sulfur range used by electric utilities was also priced from $3.50 to $5.50 per ton.

Coal of 0.6 to 1.0 percent sulfur content supplied by commercial and captive producers to electric utilities showed some price dissimilarity. Commercial producers sold it for $3.50 to $6.00 per ton; the captive supply sold for $4.50 to $8.00 per ton. However, about 90 percent of the 26 million tons of the coal with 1.0 percent or less sulfur consumed by utilities was supplied by commercial producers.

Eighty-one million tons of the reported (Form 6-1418-X) production of bituminous coal from the Appalachian Region was used to produce coke; 63 percent of the coking coal was the product of captive mines. Ninety percent of coke production was consumed by blast furnaces to make pig iron. The other 10 percent was used in foundries, gas-producing facilities, chemical manufacturing, and space heating.

Fifteen percent of the metallurgical coal sold from $5.50 to $6.00 per ton. Eighty-eight percent of the metallurgical coal (≤1.5 percent sulfur) used for coking was produced from captive mines associated with the steel industry. Ninety-three percent (28 million tons) of commercially produced metallurgical coal went to coke plants and 84 percent of this coal was priced from $5.00 to $8.00 per ton.

Commercial producers supplied about 37 million tons of the 44 million tons used by industrial, retail, and other consumers. Slightly more than one-half of the 37 million tons contained greater than 1.6 percent sulfur. The commercial coal supplied to industrial, retail, and other ran the gamut of prices ranging from $3.00 to more than $8.00 per ton.

The respondents to questionnaire 6-1418-X reported twenty-four million tons of bituminous coal from the Appalachian Region was exported in 1967. This was approximately 49 percent of the total United States exports of bituminous coal mined in the Appalachian Region. Most of the coal with 1.5 percent or less sulfur was priced at $6.01 to $8.00 per ton at the mine.

Employment

In the Appalachian Region in 1967, 597 mines reported the employment of 63,132 men. First shift employment was reported as 34,369 men (54 percent) producing 59 percent of the production. Second shift employment was 18,884 men (30 percent) producing 30 percent, and third shift employment was 9,879 men (16 percent) producing 11 percent of the production (table 11). Of the total reported work force, 45 percent was employed in West Virginia, 24 percent in Pennsylvania, 9 percent in eastern Kentucky, 8 percent in Ohio, 7 percent in Virginia, 6 percent in Alabama, and less than 1 percent in Tennessee and Maryland. Sixty-nine percent of the work force was employed by commercial mines and the remaining 31 percent was employed by captive mines.

Employment requirements for planned new mines in the Appalachian Region by type of mine, type of employee (transfer or new hire), and the job classification are shown in table 12. Employment data were reported for only 62 percent of the planned new mines (deep - 74 percent, strip - 37 percent, auger - 80 percent, and strip and auger - 0 percent). However, these reporting mines will produce 76 percent of the planned annual production and are assigned 80 percent of the new mine reserves.

TABLE 11. - Reported 1967 production and employment in the Appalachian Region by State, status, number of mines, and shift

State	Status	No. of mines	PRODUCTION (short tons) First shift	Second shift	Third shift	Total	EMPLOYMENT First shift	Second shift	Third shift	Total
Alabama	1/Com	12	2,776,037	1,352,557	38,625	4,167,219	469	289	87	845
	2/Cap	10	3,427,617	2,878,798	933,538	7,239,953	1,224	916	563	2,703
	Total	22	6,203,654	4,231,355	972,163	11,407,172	1,693	1,205	650	3,548
Kentucky, eastern	Com	76	11,588,612	6,895,523	924,982	19,409,117	2,260	1,485	480	4,225
	Cap	8	2,825,658	2,235,870	1,070,206	6,131,734	590	545	297	1,432
	Total	84	14,414,270	9,131,393	1,995,188	25,540,851	2,850	2,030	777	5,657
Maryland	Com	4	641,471	-	-	641,471	92	-	-	92
	Cap	-	-	-	-	-	-	-	-	-
	Total	4	641,471	-	-	641,471	92	-	-	92
Ohio	Com	52	20,907,735	5,629,393	3,315,546	29,852,674	2,630	1,221	708	4,559
	Cap	9	5,465,441	130,977	-	5,596,418	555	25	6	586
	Total	61	26,373,176	5,760,370	3,315,546	35,449,092	3,185	1,246	714	5,145
Pennsylvania	Com	96	18,799,883	7,206,973	5,664,121	31,670,977	3,893	1,787	1,327	7,007
	Cap	27	10,518,432	10,116,911	6,096,178	26,731,521	3,446	2,706	1,909	8,061
	Total	123	29,318,315	17,323,884	11,760,299	58,402,498	7,339	4,493	3,236	15,068
Tennessee	Com	18	1,800,846	594,193	-	2,395,039	254	166	24	444
	Cap	-	-	-	-	-	-	-	-	-
	Total	18	1,800,846	594,193	-	2,395,039	254	166	24	444
Virginia	Com	60	13,802,982	7,430,509	1,637,072	22,870,563	2,655	1,515	457	4,627
	Cap	-	-	-	-	-	-	-	-	-
	Total	60	13,802,982	7,430,509	1,637,072	22,870,563	2,655	1,515	457	4,627
West Virginia	Com	191	60,761,056	27,727,308	9,136,552	97,624,916	13,180	5,886	2,774	21,840
	Cap	34	12,615,971	11,593,155	2,589,904	26,799,030	3,112	2,343	1,247	6,702
	Total	225	73,377,027	39,320,463	11,726,456	124,423,946	16,301	8,229	4,021	28,551
TOTAL	Com	509	131,078,622	56,836,456	20,716,898	208,631,976	25,442	12,349	5,857	43,648
	Cap	88	34,853,119	26,955,711	10,689,826	72,498,656	8,927	6,535	4,022	19,484
	Total	597	165,931,741	83,792,167	31,406,724	281,130,632	34,369	18,884	9,879	63,132

1/ Commercial.
2/ Captive.

TABLE 12. - Reported employment requirements for planned new mines in the Appalachian Region

Type	Reporting companies which planned to open new mines	Companies which reported employment data	Super-vision	Elec-trical	Mechan-ical	Continuous mining machine operations	Others	Total
			TRANSFERS					
Deep	108	80	307	117	309	522	1,577	2,832
Strip	43	16	23	3	95	-	178	299
Auger	5	4	1	-	-	-	-	1
Strip and auger	4	-	-	-	-	-	-	-
TOTAL	160	100	331	120	404	522	1,755	3,132
			NEW HIRES					
Deep	108	80	1,109	794	1,381	1,572	5,455	10,311
Strip	43	16	7	-	4	-	49	60
Auger	5	4	4	2	7	-	8	21
Strip and auger	4	-	-	-	-	-	-	-
TOTAL	160	100	1,120	796	1,392	1,572	5,512	10,392
			TOTAL TRANSFERS AND NEW HIRES					
Deep	108	80	1,416	911	1,690	2,094	7,032	13,143
Strip	43	16	30	3	99	-	227	359
Auger	5	4	5	2	7	-	8	22
Strip and auger	4	-	-	-	-	-	-	-
TOTAL	160	100	1,451	916	1,796	2,094	7,267	13,524

Productive Capacity

Reported (Form 6-1418-X) bituminous coal production in the year 1967 came primarily (57 percent) from commercial deep mines with 25 percent from captive deep mines (table 13). Strip mining accounted for 15 percent of total production. Eighty-nine percent of the reserves were assigned to deep mines. The greatest production was of bituminous coal containing 0.6 to 1.0 percent sulfur which was obtained from deep mines whose reserves totaled 3,961 million tons.

Total production from all types of mining was 266 million tons with 10,560 million tons of assigned reserves (table 13). The average reserve per mine for the 682 mines reporting was 15 million tons, but the reserves for deep mines average 22 million tons per mine. Surface mine reserves averaged less than 5 million tons per mine.

The national average of bituminous coal and lignite production per mine published in the 1967 Minerals Yearbook is 0.51 million tons for mines producing over 100,000 tons. The average reported (Form 6-1418-X) for the Appalachian Region is 0.46 million tons for all types of mining. Reporting deep mines averaged 0.57 million tons per mine with commercial mines averaging 0.50 and captive mines averaging 0.82. Reporting strip mines averaged 0.26 million tons production per mine.

The planned annual coal production and reserves by sulfur content for all new mines scheduled before January 1, 1973, is reflected in tables 14 and 15. Planned production will come from deep, strip, and auger mines.

TABLE 11. - Reported (Form 6-1418-X) annual bituminous coal production and reserves for mines in the Appalachian Region by sulfur content, mining method, and commitment during the year 1967

(Million short tons)

Sulfur percent	Commercial Mines				Captive Mines				Commercial and Captive Mines			
	Number of mines[1]	Production[2]	Number of mines[1]	Assigned reserves	Number of mines[1]	Production[2]	Number of mines[1]	Assigned reserves	Number of mines[1]	Production[2]	Number of mines[1]	Assigned reserves
DEEP MINING												
≤0.3	---	---	---	---	---	---	---	---	---	---	---	---
≤0.5	7	W	4	W	3	W	5	W	10	W	9	W
0.6-1.0	152	64.65	174	2,742.00	44	32.88	52	1,219.18	196	97.54	226	3,961.18
1.1-1.5	32	13.69	40	504.47	20	18.19	20	417.76	52	31.85	60	922.23
1.6-2.0	29	8.61	20	659.41	5	7.71	8	136.01	34	16.33	28	795.42
2.1-3.0	54	W	52	W	5	W	11	W	59	42.68	63	1,584.23
≥3.1	29	W	37	W	4	W	5	W	33	22.38	42	1,967.48
(3)	3	W	5	W	1	W	---	---	4	W	5	W
Total[2]	306	152.43	332	6,977.99	82	67.32	101	2,432.25	388	219.76	433	9,410.24
STRIP MINING												
≤0.3	1	W	---	---	---	---	---	---	1	W	---	---
≤0.5	2	W	1	W	---	---	---	---	2	W	1	W
0.6-1.0	28	5.34	27	175.56	1	0.17	1	1.50	29	5.52	28	177.06
1.1-1.5	20	2.77	19	23.83	---	---	---	---	20	2.77	19	23.83
1.6-2.0	19	2.84	23	65.56	---	---	---	---	19	2.84	23	65.56
2.1-3.0	46	W	56	W	1	W	1	W	47	12.93	57	224.56
≥3.1	31	W	53	W	4	W	10	W	35	14.87	63	372.97
(3)	2	W	5	W	---	---	---	---	2	W	5	W
Total[2]	148	W	184	W	6	W	12	W	154	39.54	196	877.80

TABLE 13. - Reported (Form 6-1418-X) annual bituminous coal production and reserves for mines in the Appalachian Region by sulfur content, mining method, and commitment during the year 1967 - Continued

(Million short tons)

Sulfur percent	Commercial Mines				Captive Mines				Commercial and Captive Mines			
	Number of mines[1]	Production[2]	Number of mines[1]	Assigned reserves	Number of mines[1]	Production[2]	Number of mines[1]	Assigned reserves	Number of mines[1]	Production[2]	Number of mines[1]	Assigned reserves
					A L L T Y P E S O F M I N I N G [4]							
≤0.3	1	W	---	---	---	---	---	---	1	W	---	---
≤0.5	10	W	6	W	3	W	5	W	13	7.93	11	175.70
0.6-1.0	202	73.77	230	3,050.11	47	33.37	55	1,229.98	249	107.14	285	4,280.09
1.1-1.5	54	17.07	61	563.51	21	18.45	20	417.76	75	35.51	81	981.27
1.6-2.0	51	12.21	47	792.59	5	7.71	8	136.01	56	19.92	55	928.60
2.1-3.0	103	53.40	113	1,302.16	6	2.60	12	514.22	109	56.00	125	1,816.38
≥3.1	61	W	91	2,078.15	10	W	19	280.23	71	37.66	110	2,358.38
(3)	5	W	14	W	1	W	1	W	6	1.74	15	19.87
Total[2]	486	193.57	562	7,883.19	93	72.34	120	2,677.10	579	265.91	682	10,560.29

W Withheld to avoid disclosing individual company confidential data.
1/ Mines producing from or reporting reserves in more than one seam were counted as separate mines for each seam.
2/ Data may not add to totals shown because of independent rounding.
3/ Sulfur content not reported.
4/ Includes auger, and strip and auger mines.

TABLE 14. - Production capacities of operating and new mines, by sulfur content

(Thousand short tons)

Sulfur content	Operating Mines		New Mines	Total Mines
	1967 production	Planned production increase	Planned production	Future production
≤0.3	1/ W	---	---	1/ W
≤0.5	7,933	---	W	W
0.6-1.0	107,014	4,524	34,100	145,638
1.1-1.5	34,828	510	2,330	37,668
1.6-2.0	19,920	W	W	W
2.0-3.0	56,003	W	W	91,375
≥3.1	38,353	3,384	15,410	57,147
(2)	1,742	W	W	28,652
Total	265,794	12,870	113,200	391,864

1/ Included in ≤0.5 percent sulfur content.
2/ No sulfur value reported.

TABLE 15. - Reported annual production and reserves by sulfur content for all new mines scheduled before January 1, 1973 in the Appalachian Region

(Million short tons)

Sulfur content	No. of mines	Planned	Committed	Percent available	Assigned reserves
COMMERCIAL					
			Deep		
≤0.3	0	---	---	---	---
≤0.5	1	W	0	100	W
0.6-1.0	45	31.91	13.59	57	1,643.81
1.1-1.5	6	W	W	72	63.28
1.6-2.0	8	1.35	W	W	41.77
2.1-3.0	18	27.46	11.64	58	899.97
≥3.1	8	9.86	9.71	2	W
(1)	13	25.61	25.13	2	705.70
Total	99	98.42	60.56	38	3,845.99
			Strip		
≤0.3	0	---	---	---	---
≤0.5	0	---	---	---	---
0.6-1.0	10	1.09	W	W	9.74
1.1-1.5	9	0.70	W	W	2.64
1.6-2.0	3	0.45	0.15	67	2.19
2.1-3.0	8	2.67	0	100	W
≥3.1	10	W	0.34	W	W
(1)	2	W	0	100	W
Total	42	10.76	1.00	91	101.06
COMMERCIAL AND CAPTIVE					
			All types 2/		
≤0.3	0	---	---	---	---
≤0.5	2	W	W	76	W
0.6-1.0	63	34.10	14.95	56	1,938.54
1.1-1.5	15	W	W	78	65.92
1.6-2.0	12	2.20	0.59	73	W
2.1-3.0	30	31.58	13.09	59	943.90
≥3.1	21	15.41	10.85	30	560.40
(1)	17	26.79	25.13	6	738.30
Total	160	113.20	65.32	42	4,309.63

1/ No sulfur value reported.
2/ Includes strip, deep, and auger mines.

Of the 109 million tons of planned commercial production, 62 million tons from deep and strip mines was committed on long term contract and 47 million tons of the planned production would be available for purchase on the open market.

Planned commercial deep mine production will be about 98 million tons, which is equal to 87 percent of total planned production. Sixty-one million tons is committed.

Planned commercial strip mine production will be about 11 million tons, which is only 10 percent of the total planned production for all mines. Ten of the 11 million tons of the planned production will be available. Only 1 percent of the planned commercial strip production was reported to be 1.0 percent sulfur or less.

Planned commercial and captive production from all types of mines will total 113 million tons. Twenty-four percent of the planned commercial and captive coal production was not reported as to sulfur content.

ANALYTICAL DATA

About 26,000 sulfur analyses and 1,500 nitrogen analyses for bituminous coal from the Appalachian Region are stored in a computer data bank maintained by the Bureau of Mines. Most of the coal analyses are of either tipple or delivered samples and represent the coal after it has been mined and prepared for market (not as unmined coal in place). Many of these analyses are from the same mines and seams because this was the coal which was marketed and tested. Therefore, some coal seams are very well represented whereas others are poorly represented. Nevertheless, the data is a useful indication of coal quality in the Appalachian Region.

Because of the large variance, the statistical means for the Appalachian Region should be used with caution. The random variance of the sulfur content is large when applied to large geographic areas, i.e., regions and States. However, as the size of the areas is reduced, such as to a county or a coal seam within a county, the variance is reduced materially and the mean values become more meaningful.

The statistical analyses of sulfur are given in tables 16 and 17 and are submitted below:

	Number of analyses	Mean	Ranges	Variance	Standard deviation
Raw	17,584	1.7	0.2-9.4	1.3239	1.15
Washed	8,196	1.4	0.3-6.7	0.8769	0.94
Analyses	1/25,858	1.6	0.2-9.4	1,2096	1.10

1/ This total does not agree with the sum of raw and washed due to cases where analyses were made on combined raw and washed sizes.

TABLE 16. - Average sulfur content of bituminous coals from the Appalachian Region by State

	Alabama	Kentucky (eastern)	Maryland	Ohio	Pennsylvania	Tennessee	Virginia	West Virginia	Total Appalachian Region
Number of analyses	1,686	2,776	385	2,312	5,264	1,204	1,963	10,268	25,858
Mean	1.1	1.1	1.7	3.2	2.0	1.4	0.8	1.4	1.6
Range	0.3-3.9	0.2-5.4	0.5-5.8	0.5-9.4	0.4-8.1	0.5-6.4	0.4-3.7	0.4-6.2	0.2-9.4
Variance	0.2826	0.4993	0.8129	1.452	0.8488	1.1368	0.1002	1.0346	1.2096
Standard deviation (±)	0.53	0.71	0.90	1.20	0.92	1.07	0.32	1.02	1.10
95 percent probability level ±2(Standard deviation)	1.06	1.42	1.80	2.40	1.84	2.14	0.64	2.04	2.20

TABLE 17. - Average sulfur content of (raw and washed) bituminous coals from the Appalachian Region, by State

	Prep	Alabama	Kentucky (eastern)	Maryland	Ohio	Pennsylvania	Tennessee	Virginia	West Virginia	Total Appalachian Region
Number of analyses	R	946	2,272	361	1,660	4,019	1,120	1,206	6,000	17,584
	W	737	489	19	642	1,232	58	748	4,271	8,196
Mean	R	1.1	1.2	1.6	3.2	2.0	1.5	0.8	1.6	1.7
	W	1.0	1.0	2.6	3.0	1.9	1.2	0.7	1.1	1.4
Range	R	0.3-3.9	0.2-5.4	0.5-5.8	0.5-9.4	0.4-8.1	0.5-6.4	0.403.7	0.4-6.2	0.2-9.4
	W	0.3-3.9	0.5-3.9	1.9-3.1	0.7-5.9	0.6-6.7	0.5-5.0	0.4-1.8	0.4-5.1	0.3-6.7
Variance	R	0.3199	0.5439	0.7909	1.6718	0.9320	1.1587	0.1216	1.2156	1.3239
	W	0.2299	0.2862	0.1093	0.8404	0.5588	0.9465	0.0640	0.6444	0.8769
Standard deviation (±)	R	0.57	0.74	0.89	1.29	0.97	1.08	0.35	1.10	1.15
	W	0.48	0.53	0.33	0.92	0.75	0.97	0.25	0.80	0.94
95 percent probability level ±2 (Standard deviation)	R	1.14	1.48	1.78	2.58	1.94	2.16	0.70	2.20	2.30
	W	0.96	1.06	0.66	1.84	1.50	1.94	0.50	1.60	1.88

R - Raw.
W - Washed.

A statistical summary (table 18) shows a total of 1,519 analyses of nitrogen content with a mean value of 1.5 percent and a variance of 0.0410. At a 95 percent probability level, the deviation around the mean is plus or minus 0.4, which indicates the nitrogen value should be between 1.1 percent to 1.9 percent. It appears that the mean of 1.5 percent can be used with confidence.

Because coal is a heterogeneous material and has varying characteristics, problems exist in selecting coals for currently operating coal-burning plants and in the design of future plants. Each of the coal properties, chemical and physical, influences the combustion of coal and the significance of the properties varies appreciably with different types of coal-burning equipment. T. S. Spicer (6) rated the coal properties significance for different types of equipment, as shown in table 19. A more detailed list of properties and significance is given in, "Significance of Laboratory Tests of Coal and Coke for Combustion" (3). The uses of coal analyses and their limitations are discussed in detail by Rees in, "Chemistry, Uses, and Limitations of Coal Analyses" (5).

TABLE 18. - Nitrogen content of bituminous coals from the Appalachian Region, by State

	Alabama	Kentucky (eastern)	Maryland	Ohio	Pennsylvania	Tennessee	Virginia	West Virginia	Total Appalachian Region
Number of analyses	58	177	8	85	445	65	128	553	1,519
Mean	1.7	1.7	1.4	1.4		1.7	1.5	1.5	1.5
Range	1.4-2.1	0.9-2.8	1.2-1.9	1.1-1.6	0.7-2.1	1.2-2.4	1.1-1.9	0.7-2.1	0.7-2.8
Variance	0.0345	0.0573	0.0719	0.0146	0.0233	0.0610	0.0153	0.0282	0.0410
Standard deviation (±)	0.186	0.239	0.268	0.121	0.153	0.247	0.124	0.168	0.202
95 percent probability level ±2 (Standard deviation)	0.372	0.479	0.536	0.242	0.305	0.494	0.247	0.336	0.405

TABLE 19. - Coal properties significance chart for combustion performance

	Firing methods					
	Single retort	Multiple retort	Traveling grate	Spreader stoker	Pulverized firing 1/	Cyclone
Size consist (as fired)	V	I	I	V	V	V
Moisture 2/	M	M	N	M	V	M
Caking index 3/	I	I	V	M	N	N
Ash fusibility	I	I	M	M	I	V
Grindability	N	N	N	N	V	N
Friability	M	M	M	M	N	N
Volatile matter	M	M	M	M	I	M
Fixed carbon	N	N	N	N	M	N
Ash content	M	M	M	M	M	M
Calorific value	N	N	N	N	N	N
Ash viscosity	M	M	M	M	I	V
Ash composition	(4)	(4)	(4)	(4)	(4)	(4)

Rating Code: V - Very important
I - Important
M - Minor importance
N - Little or no importance

1/ Degree of fineness is a better term for Pulverized Firing.
2/ Surface moisture is more critical than inherent moisture. Moisture is very important from the standpoint of plant flowability.
3/ Some engineers are attempting to use the FSI as an index of the degree of caking.
4/ Ash composition is very important as it affects fireside fouling, but not important to combustion.

Source: Modified from: Spicer, T. S., Effect of Coal Characteristics on Combustion Performance, Coal Utilization, vol. 14, No. 11, 1959, pg. 22.

SUMMARY

In the Appalachian Region, a total of 31.4 billion tons of bituminous coal was reported as remaining reserves as of December 31, 1967. Of this total, 13.4 billion tons would be recoverable at prices $2.00 per ton above the 1967 f.o.b. prices. The expected production of coal, assuming expanded production from the 1967 rate of operating mines, plus planned new production in 1973 will be 392 million tons.

Thirty-nine percent of the reported remaining reserves contained 1.0 percent or less sulfur, most of which is in West Virginia. Also, over half of the reported remaining reserves are in West Virginia.

Ninety-one percent of the companies producing more than 100,000 tons of coal in 1967 reported remaining reserves of 31.4 billion tons, a small fraction of the total estimated remaining reserves. Field work indicated that large reserves are under ownership other than the reporting companies and that considerable time and effort would be necessary to determine the magnitude and quality of reserves in various ownerships. Published estimates of coal resources include coal which is not necessarily minable. The reserves reported on Form 6-1418-X include the coal considered by its owners to be of a minable thickness, depth, and quality to be marketable in the foreseeable future.

Reported remaining reserve of commercial coal was 12.5 billion tons. Of this, 6.4 billion tons is reported as recoverable. Reported remaining reserves of captive coal was 2.7 billion tons. Only 701 million tons was reported as recoverable.

The ownership of land containing coal reserves in the Appalachian Region is divided among Federal agencies, State agencies, and private owners. About 87 percent is in private ownership, and 12 percent in Federal and State ownership. Frequently, coal rights are segregated from the surface rights, making the determination of coal ownership a complex process.

Reported production of coal in the Appalachian Region during 1967 was 266 million tons, 68 percent of the annual production canvass. West Virginia produced 115 million tons; Pennsylvania, 57 million tons; and Ohio, 35 million tons. Coal production of 1.0 percent or less sulfur was 115 million tons. West Virginia produced 65 million tons of this coal.

Of the reported 266 million tons of coal production in 1967, electric utilities consumed 44 percent; coke plants, 30 percent; and industrial, retail, and other industrial uses, 17 percent. Exports accounted for 9 percent. Commercial operations produced 194 million tons and captive mines, 72 million tons. Twenty-two percent of the coal consumed by electric utilities had a sulfur content of 1.0 percent or less. Sixty-six percent of the coking coal was in the category of 1.0 percent or less sulfur.

In the Appalachian Region during 1967, employment at 597 mines was 63,132 men. Sixty-nine percent worked in commercial mines and the remainder in captive mines. West Virginia accounted for 45 percent of the employees. For reported new mines scheduled to be in operation by 1973, a total work force of 13,524 men will be required. New hires will total 10,392 men and transfers will be 3,132 men.

This survey indicates that planned annual production for new mines scheduled by 1973 will total 113 million tons. Eighty-seven percent will be from deep mines and 10 percent from strip mines. Thirty percent of the planned production will be at a sulfur range of 0.6 to 1.0 percent. Twenty-eight percent of the planned production will be in the range of 2.1 to 3.0 percent; and 14 percent at a range in excess of 3.0 percent. Twenty-four percent of the planned production was not identified by sulfur range.

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